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CONTENTS

	PAGE
Historical Relationship of Mining, Silicosis, and Rock Removal. TREVE HOLMAN	1
The Control and Elimination of Silicosis in the West Coast Haematite Iron Ore Industry. JOHN CRAW	30
Byssinosis in the Cotton Trade. C. I. C. GILL	48
Studies in Occupational Morbidity (1). W. T. RUSSELL, G. P. B. WHITWELL, and JOHN A. RYLE	56
The Hand of the Plant Potter : A Stigma of the Market Gardener. HENRY COHEN	62
Obituary	64
Book Reviews	65
British and Foreign Official Publications	66
Abstracts	67
Proceedings of the Association of Industrial Medical Officers	76

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HISTORICAL RELATIONSHIP OF MINING, SILICOSIS, AND ROCK REMOVAL

BY

TREVE HOLMAN

Camborne, Cornwall

(RECEIVED FOR PUBLICATION, AUGUST 7, 1946)

Introduction

The interwoven relationship of mining, silicosis, and rock removal has existed for thousands of years, from long before historical record. Mining, of all collective enterprise, is the most ancient. Man's ability to find, form, and use flint tools was an early step in his development. Some 10,000 or more years ago underground work began with the sinking of shafts and driving of tunnels for flints for use as knives, axes, arrow-heads, and other implements. In many European countries evidences of such neolithic work have been discovered. Mining in antiquity carried its hazards as it does to-day, but in a far more aggravated form. Violent death was an ever-present danger. Improvement has occurred over the centuries, but due to the nature and conditions of his employment the miner has always been susceptible to occupational disease.

The technique of rock removal was from the earliest days an important concomitant of mining for metals. Its development was the principal factor in the advancement of mining itself.

Dust created by rock removal is by no means confined to rock drilling. Blasting, shovelling, transporting, crushing, winding to surface, are operations during which dust may be, and generally is, released into the atmosphere. These factors are not examined in this review, which is confined to the drilling of holes in rock. An attempt is made to outline the progress in rock drilling along each of the three drilling operations, drifting, underhand stoping, and overhand stoping, and to show how the gravity of resultant occupational disease increased with the intensity of operations until a belated realization of the problem called a halt. Great improvements have been made, but the effect has been uneven in this country. Unless safeguards for the protection of miners' health are universally adopted, labour may seek surface employment, or the recompense demanded may injure dependant industries. The safeguards are well known and well tried. No mine or quarry should operate without them.

Period I.—Prehistoric Surface Excavations and Shallow Holes

Even in the earliest times mining in its most elementary form appears to have caused diseases. It has been suggested by Rosen that ancient miners suffered from silicosis, as signs of pneumonoconiosis have been observed in prehistoric man. In Egyptian mummies anthracosis and pleural adhesion have been found. Flint-knapping, the oldest of industries, remains to this day a source of mortality from phthisis through flint dust. It is, therefore, a reasonable assumption that in period I, as the only tools available, other than horn, were of flint, the working of this material caused a serious liability to lung disease.

As regards actual mining, the methods of excavation were entirely by hand and, whilst slow and extremely laborious, were relatively free from dust. The workings being shallow, natural ventilation no doubt sufficed to keep them supplied with breathable air. It is probable that the worst dangers which faced the prehistoric miner were from falls of ground and inrush of water.

Period II.—Deeper Mining by Manual Labour

This long period reaches from the dawn of recorded history down through mediaeval times to the earliest days of the industrial revolution. The work remained slow and laborious as mechanization had not begun, but there was a gradual improvement in the tools used. Flint was superseded by bronze of a steadily improving quality, which in its turn gave place to iron, also subject to steady improvement as time went by. When metal mining began is unknown, but there is little doubt that bronze tools were in use 6,000 years ago. Large-scale mining operations were carried on in Egypt with the aid of metal tools. The removal of hard rock was

achieved by building a fire against the face and then by throwing water on the heated rock. The first specific reference to 'fire setting' in mining is by Agatharchides in the second century B.C. (see Hoover, 1912). The same method was customarily used through Greek, Roman, and mediaeval times on into the seventeenth century, when it was

PLATE I.

gradually displaced by blasting with gunpowder. Until the invention of safety fuse by Bickford in 1831 the blasting powder was ignited from straws filled with fine-grained powder, and frequent accidents occurred. Although the working conditions as mentioned by the ancient writers were of appalling description, yet it is possible that defective ventilation, falls of ground, and hook-worm were the chief causes of casualties. The production of dust through mechanical drilling operations had not yet begun, but some dust was caused by the work, and Pliny mentions the use of bladder-skins as primitive respirators to cover the mouths of miners.

After the fall of Rome the records of mining ceased until the great work of Agricola was published in 1556 in Latin, under the title of 'De re Metallica.' It was translated by Herbert Hoover the American Mining Engineer in 1912, and was published in a well-produced limited edition. It is illustrated by the original woodcuts, which are of the greatest technical interest. Agricola (Plate I) made a thorough investigation into mining practices in Germany, which was then the leading country in the industry. Being a Doctor of Medicine, he included in his observations an account of the diseases and accidents prevalent amongst the miners.

The breaking of rock followed the earlier methods of hewing with metal tools, except for the harder rocks, where fire was used. In the drier mines considerable trouble from dust was experienced. Agricola says, 'If the dust has corrosive quality it eats away the lung and implants consumption in the body.' He makes the statement that, in the mines of the Carpathian Mountains, women are found who have married seven husbands in turn, all of whom died from consumption. With the introduction of gunpowder for blasting at Schemnitz by Casper Windt in 1627 the drilling of holes began. A form of machine drill was tried in 1636, but it may be taken that during the period under review practically the whole of the work was carried out by hand.

There is no doubt that one of the causes of the grave mortality amongst the miners was their low social status and entire lack of sympathy and care from the rest of the population. In the earlier days of this period only slaves were used underground, who were driven at work until they died. Even in the latter years of the period, miners were regarded as people apart and their laws and conditions of life were separate from those of the rest of the community. For instance, in Cornwall the tinners were governed by the Stannary Courts (Lewis). In spite of a somewhat contemptuous valuation there is no question that great skill was essential and was present. A man's life was in his own hands, and carelessness and ignorance was repaid by injury or death.

Period III

Mining.—This period carries the story from 1700 to the middle of the Victorian era. During this time the mines were increasing rapidly in depth, due to the great improvement in the pumping of water to keep the mines dry. Steam had been set to work by Newcomen in 1712, and this great advance had been continued by a succession of engineers—Smeaton, Watt, Murdock, Hornblower, Trevithick, Woolf. By the close of this period mines could be worked to a depth of 1,800 or more feet.

'Ventilation was becoming more difficult, as rock temperatures were rising steadily with the increase in depth. In the St. Day district in Cornwall it is recorded that at Poldice Mine the water from the 184 fathom level (1104 ft.) registered 100° F. Air in the deeper levels of the mines was between 80° and 100° F. (Jenkin). Truscott states: 'The rate of the increase of temperature with depth, known as the geothermal gradient, varies from region to region,

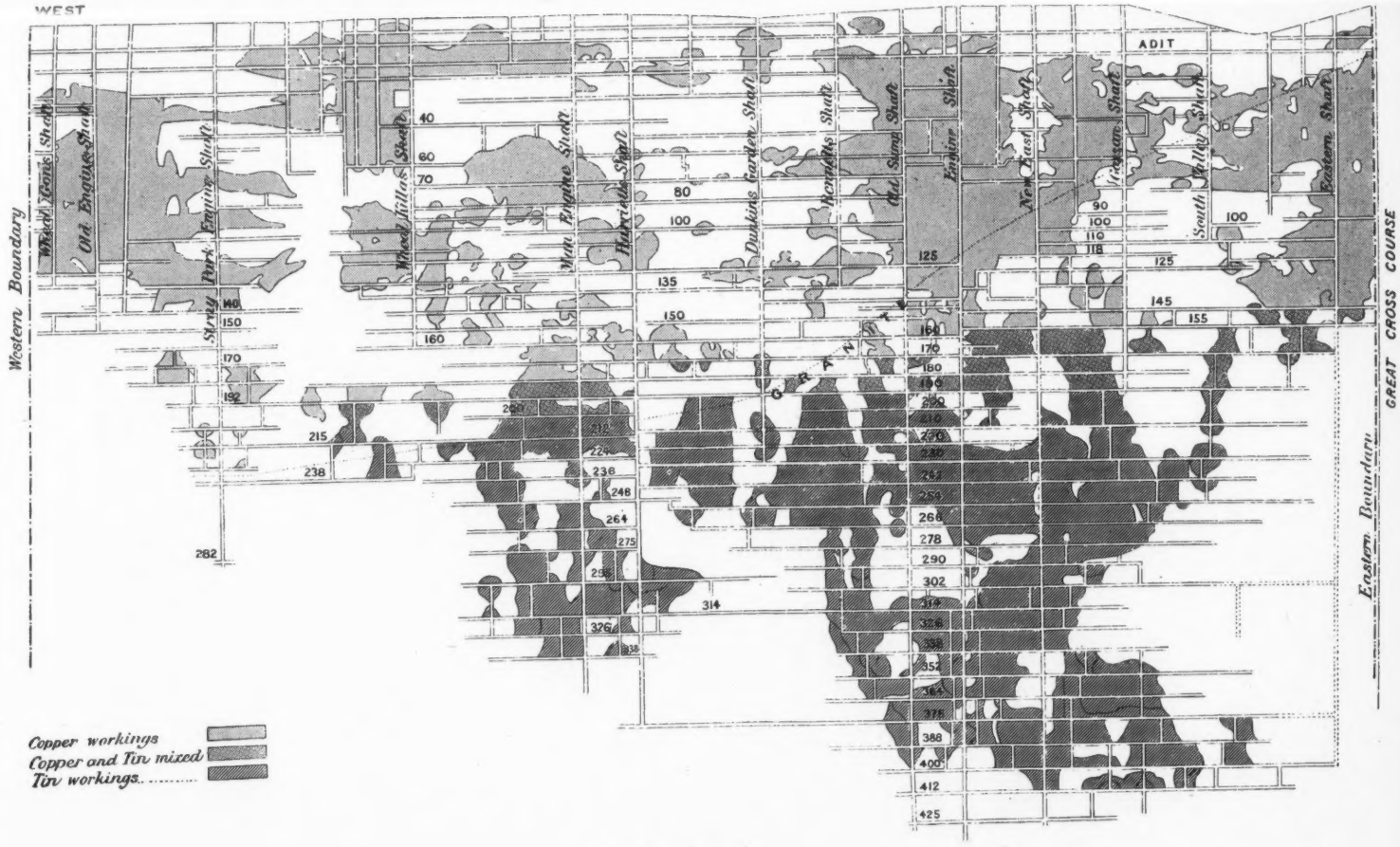


PLATE II.—Dolcoath Main Lode.

it is lowest where the country has been long a land surface and long been free from intrusion and movement. On the Witwatersrand there is a rise of 1° F. for every 212 ft. On the Indian Kolar Goldfields the gradient is 1° F. for every 150 ft. In the British and European Coalfields the figure is 1° F. for 65 ft.' At the time when these great temperatures were being met with, many of the mines were without any proper ' dries ' or changing-houses. Long draughty sheds without doors or windows, where the wind whistled through on the half-naked men, were frequently the only places provided for the miners on coming up from the great heat below. As late as 1842, the men in a great mine like Fowey Consols had no real ' dry,' no warm water to wash with, whilst in winter their shoes were sometimes frozen in the chests on the surface (Jenkin).

Silicosis.—During this period occupational disease in general was being intelligently investigated. Mining was one of the industries brought under view owing to a realization of the shortness of life of miners as a class.

In 1700 Ramazzini published the first treatise on occupational medicine (see Rosen). He was an eminent Italian physician of Modina. His book laid a firm foundation for the further study of occupational diseases. The chapter of immediate interest is on 'The Diseases of Metal Diggers.' He mentions that in antiquity mining was regarded as a suitable punishment for criminals. He goes on to state that this opinion was still widely held in his day and adds, ' Indeed it seems to be a doubtful case whether we ought to reckon it a good and pious office to prescribe physic to such wretches and thereby prolong a miserable life.' Nevertheless, he continued his investigations and suggested that any lung pathology in such workers might be due to deposits of the metallic elements which were contained in their bodies, and that the same thing might happen in the lungs of the workmen. In discussing prophylactic measures he suggests ventilators and respirators, and that the miners be provided with boots and gloves to protect their legs and hands. This wise suggestion for the use of gloves is still observed only in Canada and the United States. In many of the mines in Canada they are compulsory.

In the collieries in England as in the mines and collieries elsewhere, the miner's life was one of great hardship. For instance, it is said that in the early days of the eighteenth century in the gassy mines on the Tyne putrescent fish were employed as an illuminant owing to danger from explosion. An old Cornish version of the tale has it that a dish of mackerel showed up a rich lode proper.

Investigations were continued both in this country and in Germany. In 1745 Henkel (see Rosen) drew attention to a method of testing the presence of dust by placing a smooth stone or a glass plate in a dry spot whilst work was going on in the mine; he mentioned the astonishment at observing how much dust collected in this way within 6 to 8 hours. This was probably one of the earliest, if not the first, description of an attempt to measure concentration of dust in mine air.

In 1799 Thomas Beddoes said that the inhalation of dust might be conducive to the establishment of a tuberculous condition. He recommended a change of occupation. In 1832 was published an important work by a Leeds physician, Charles Thackrah. Six pages are devoted to the diseases of miners. He draws attention to injury to health from dust, and suggested a ' common watering ' of the stone being worked. He recommends periodic health examinations for all workers, proper muscular exercise, frequent baths at regular intervals, with proper bath facilities and plenty of fresh air. Nearly 100 years were to pass before these recommendations received the attention they deserved.

In 1859 Schirmer pointed out that detrimental influence of bituminous coal dust on the lungs was best prevented by adequate ventilation of the pits and by ' isolating ' the workers from the atmosphere filled with coal dust by which they were surrounded. This ' isolation ' would be achieved most expediently by the wearing of Jeffrey's respirator. The workers should also wash frequently, take frequent warm baths, and change their clothes oftener. In mentioning these suggestions Rosen adds, ' Yet while physicians proposed various prophylactic measures they were in no position to make them effective. The very fact that the same suggestions recur in the writings of various authors, at different periods, is sufficient evidence that they exercised little or no influence on existing conditions.'

Mine inspection during this period was a complete travesty. In the evidence given before a Parliamentary Select Committee in 1865 the following was stated regarding the inspection of the collieries in one important district. There was one inspector, an old man of 70 years of age, to inspect more than 130 collieries. He had been in one pit once in seven years. This is understandable when it is realized that in 1865 Great Britain had 3,217 coal mines to be visited by 12 inspectors; or about 268 collieries to every inspector.

However bad the conditions were in the collieries, they were much worse in the Cornish mines. Barham, in 1871, wrote a report after investigating conditions in Cornwall and Devon. He compared

PLATE III.—Hand drilling (drifting).

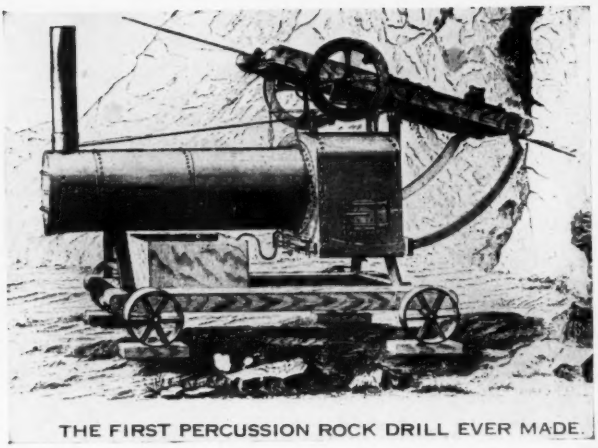


PLATE IV.

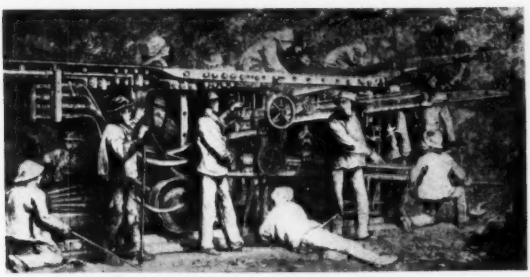


PLATE V.—Mont Cenis Tunnel.

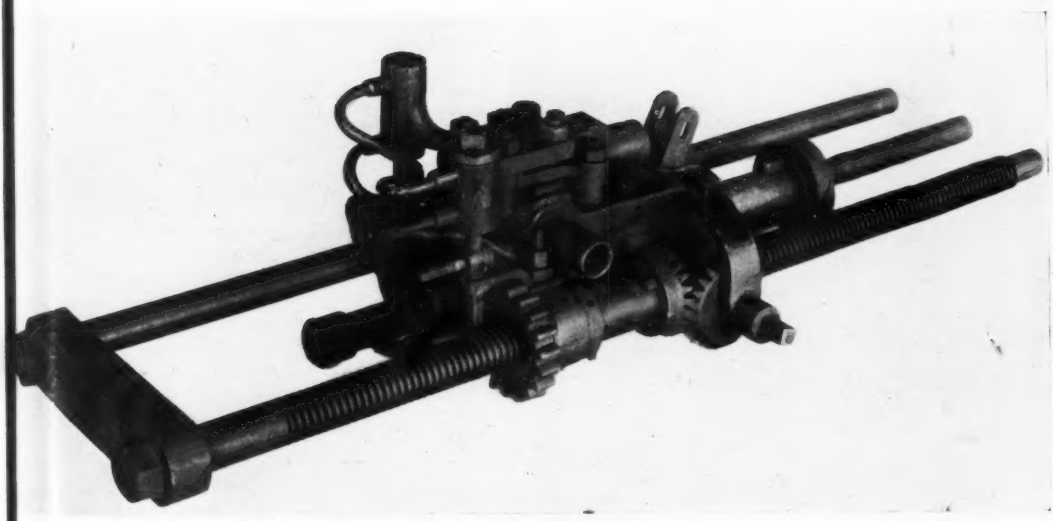


PLATE VI.—Doering drill, 1867.

the difference in mortality between miners and non-miners and stated that it was not very great until after the age of 35; then it increased rapidly, till from 45 to 65 there was a very pronounced excess among the mining class. He compared the mortality of the Cornish miner with that of the other great mining districts and that of all occupations in the whole of England. Out of 10,000 males who attained the age of 15, there were registered as dying of all lung diseases :

All Occupations	Miners in			
In England	Cornwall	Stafford	Durham	S. Wales
2,866	5,596	2,655	1,958	3,037

In spite of evidences which had accumulated regarding the danger of dust, the conclusions reached in 1862 by the Royal Commission appointed to study health conditions amongst metal miners stated that miners' phthisis was due to bad hygienic conditions rather than to the action of inhaled dust. This was unfortunate, as it diverted attention from the dust problem. However, in 1865 Greenhow investigated a portion of a black lung obtained from a coal miner, in which he recorded the presence of silica. He attempted to detect this by the use of polarized light. He had already used this method for the microscopic identification of silica particles in the lung of a razor-grinder. This is probably the earliest instance of the use of polarized light, and although unsuccessful, it is worth noting. The method actually used was to expose the residue to the fumes of hydrofluoric acid, which caused dissipation. Rosen states, 'within these broad outlines Greenhow's conception approaches quite closely the modern views on the subject as summed up and expressed in the generic use of the term silicosis.'

Rock Removal.—Work was most arduous under the then existing conditions, as the drilling of holes for blasting and the removal of the blasted rock was by hand (Plates III—drifting ; XIX—underhand stoping ; XXVIII—overhand stoping). Some plug and feather breakage of rock was used in which taper wedges were driven by sledge hammers into holes already drilled, thus splitting off pieces of rock. Some fire setting was still in use, and Collins records that in Königsberg an advance of from 5 to 20 ft. per month in headings was accomplished (Hoover), but blasting had become the normal method of rock removal and, as recent research has proved, was a very prolific source of dangerous dust. Blasting operations were crude and full of danger arising not only from premature explosion, but from picking out the holes which frequently misfired. Dr. Paris (Jenkin, p. 218) describes more than eighty accidents from this source which occurred in a short space in the Cornish Hundred of Penwith alone. Unlike the blasting accidents of to-day, the sufferers were more often mangled than killed outright. The numbers of men in the mining districts with faces blackened and blinded in one or both eyes, or else lacking two fingers of the right hand, used formerly to be very great.

Dynamite was introduced by Nobel in 1867. It was safer to transport, handle, use, and store than black powder; at the same time it was six times more effective. The increased shattering effect on rock no doubt greatly increased the quantity of dust liberated.

Machine drills were introduced towards the end of the period but were crude, heavy, and troublesome. The first percussive rock drill was made by Couch in Philadelphia in 1849 (Plate IV). Fowle, also of Philadelphia, followed in 1851, using the direct stroke and self-rotating principle. The first great drilling project (Plate V) which did much to concentrate the attention of civil and mechanical engineers on the problem of rock removal was the driving of the Mont Cenis tunnel in 1854 (Darlington). Compressed air was introduced, and a modified form of the Fowle drill was developed by French and Italian engineers. Later Burleigh improved the Fowle drill in the U.S.A., and used it in driving the Hoosac tunnel—another spectacular achievement. Thereafter designs came quickly. Between 1849 and 1870 sixteen different rock drills were brought out, but all were immature and a continuous source of trouble. Many of the designs were most ingenious and incorporated features such as automatic advancement of the machine as drilling proceeded, combined with automatic rotation (Plate VI). These features were far ahead of their time, and it is only in the last ten years that they have been solved in a practical and reliable form. The failure of the early drills was due less to faults in conception than to faults in execution. Owing to the immature state of metallurgical science the metals used could not withstand the work, nor had machine tools reached that standard of exact production which the designs required.

Considerable dust must have been created by these machines as little or no attempt was made to prevent it. The rate of drilling was very low and, therefore, less dust would have been created than was made by the more efficient rock drills of the next period.

Period IV

Mining.—The fourth period covers from mid-Victorian times to 1912. During this time immense

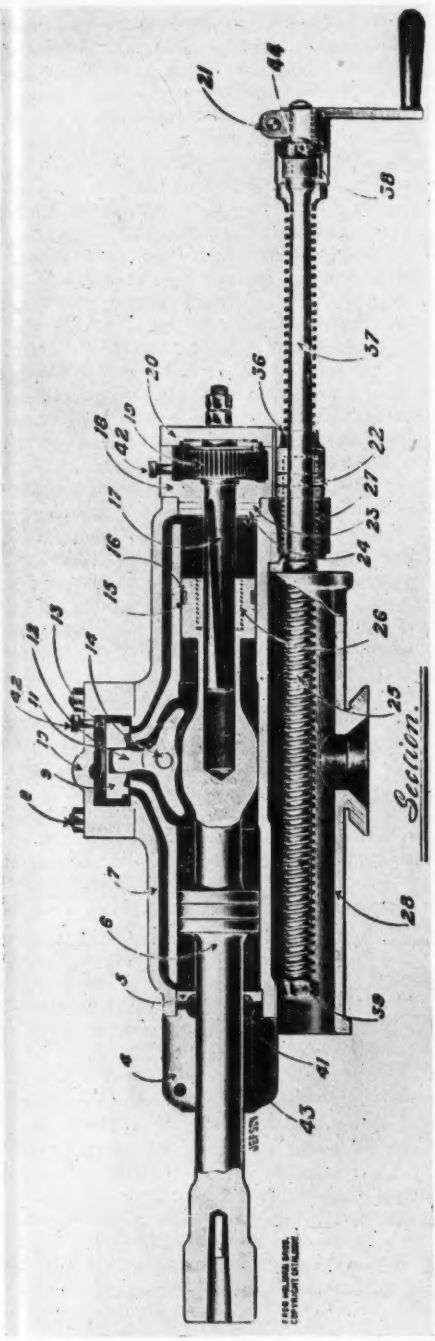


PLATE VII.—Rock drill of 1885.

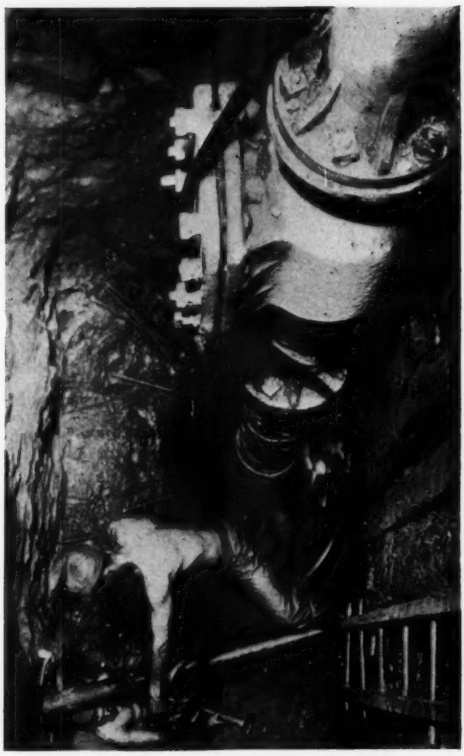


PLATE IX.—Early shaft sinking.

PLATE VIII.—Rock drill of 1890, drifting.

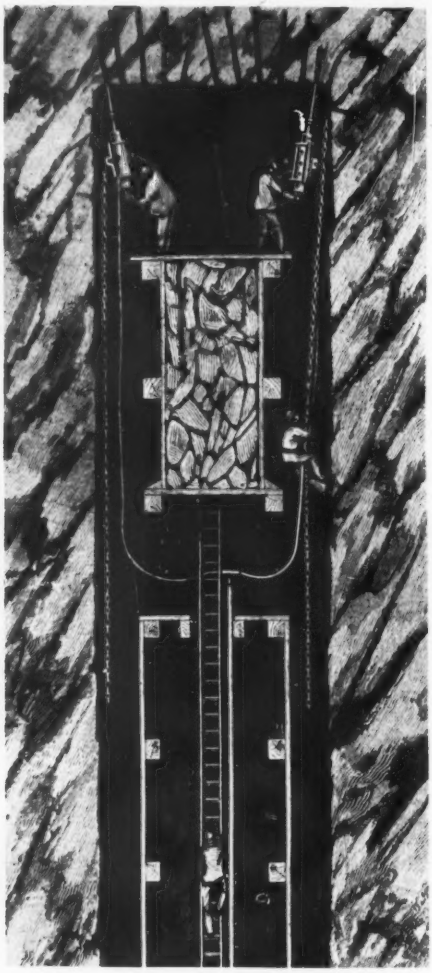


PLATE X.—Early shaft raising.

mining activity took place all over the world. Gold was found in great quantities in South Africa, California, and Western Australia. Large deposits of copper were discovered in the United States, South America, Spain, and elsewhere. Rich tin mines were opened in Bolivia. Cornish miners performed a most important task in this great activity, which was in fact in many cases initiated by them. This was due to the serious slump in Cornish mining towards the end of the nineteenth century. Some of the richer mines were exhausted and the price of tin and copper fell, owing to the rich deposits discovered overseas. Also a big change had been taking place in social conditions in England, as pewter, which had consumed vast quantities of tin, passed out of fashion and earthenware was substituted for it.

Silicosis.—The continuation of these circumstances caused a vast dispersal by emigration of Cornish miners. Lord Courteney of Penwith investigated the effect on the county and states that between 1851 and 1891 170,000 Cornish miners emigrated overseas. They carried with them the virtues and also, it is feared, the vices of Cornish mining methods. The most serious of these latter was the total disregard of the danger of dust. In spite of the great scale on which some of the Cornish mines had been worked, as is shown by the section of Dolcoath Main Lode (Plate II), no attempt had ever been made to mitigate this danger, and even towards the end of the period the miner who came up to ' grass ' at the end of the shift without being as white as a miller and covered from head—eyes, nose, and mouth—to foot in dust was regarded as not having done a proper shift's work by the Bal Captains. Some of the more careful men provided themselves with a sponge which they kept in their mouths. The particular mining operation which caused the most serious harm was that of the ' raising ' of shafts. Plate X clearly indicates this practice. When it is realized that no method of water injection was used and that men were looking upwards with the fine siliceous dust falling on their faces, it is clear that these ' raises ' were death traps of the most savage description.

Rosen cites Ogle who wrote, in 1892, that Cornish miners still suffer from an excessive rate of mortality while coal miners were more fortunately situated. The following table gives comparative figures:

Age 25–65	Phthisis	Lung diseases	Phthisis and lung diseases
Cornish Miners	348	231	579
Coal Miners	64	102	166

From these figures it is evident that the mortality from phthisis among Cornish miners was exceedingly great. Ogle states that it is from five to six times as high as that of fishermen, who have a low rate of mortality. Apparently health conditions amongst Cornish miners had not improved at all in the thirty years from 1862 to 1892. From the various

reports and tables published at the end of the nineteenth century it is clear that the period in life when the miner's occupation began to have the most serious effect was after 55. It was then that respiratory diseases took their toll.

Medical investigation was being directed more and more to occupational disease arising from dust. Rosen quotes Eulenberg, writing in 1876, as drawing an important conclusion on this problem. This was the significance of the quartz content of various dusts. He emphatically pointed out the dangerous qualities of this mineral. Shortly before, Hirt divided dust into the categories of organic and inorganic, and again into metallic and mineral varieties. Within these various groups he differentiated between pointed or sharp-edged dusts that might injure the tissues, and dull round particles.

The importance of this difference is discounted nowadays but attention is drawn to the fact that the siliceous crystals found in the rocks of the Witwatersrand in South Africa are of needle-like form. Silicosis has been a grave scourge there for many years, and, in spite of the preventive measures taken, the disease has not been eliminated. On the other hand, in the rocks of the Kolar goldfields in South India the needle-like form of crystal is absent. No water is used underground owing to the great humidity, and almost all drilling is done by the reciprocating type of rock drill, similar to that shown in Plate XX, p. 17. As explained on p. 10, this type of machine does not require an air blast to remove dust from the hole, but nevertheless it proved dangerous on the Witwatersrand. Silicosis has only recently assumed the dimensions of an occupational disease in the Kolar goldfield; and, therefore, despite the current solubility theory of silicosis, it is possible that Kolar dust, owing to its 'dull round' form, may not be so deeply penetrative and accumulative. It might, therefore, be less able to exert the same toxic effect as that of the Witwatersrand. 'Good housekeeping' in the way of ventilation is in force; but it is clear that in drilling dry the miner would be very rapidly 'infected' by dust, and silicosis would have been a grave problem long since if the dust were as deleterious as on the Witwatersrand.

As this period advanced the death rate from silicosis caused people to direct attention more and more to suppression of dust in rock drilling at the source. In the early days of the period, in 1879, the use of a stream of water directed at the point which was being bored was found by Hesse and Harting to diminish the formation of dust almost completely. It was probably during the driving of the St. Gothard tunnel that the use of water was first tested, and it was the news of these experiments that caused Hesse and Harting to make their scientific investigation. As a result of their experiments they proposed the following prophylactic measures: (1) obligatory introduction of wet boring; (2) the institution of adequate ventilation; (3) the introduction of cages for the transportation of miners up and down shafts; (4) the furnishing of working clothes, including shoes for the men; (5) the institution of a dressing-room within the shaft building—heated in winter—where the miners could change their clothes on leaving and entering the pit. It is interesting to reflect that these recommendations were published 67 years ago, and yet the vitally important recommendation No. 1, and the hardly less important No. 5, are not yet obligatory or universal in this country.

Rock Drills.—There was a remarkable advance in the mechanical developments in mining as they affect rock drilling. There is a theory that all mechanisms pass through three stages. The first stage is the inception of the idea when a crude appliance gives an indication of what is possible. In the second stage the machine becomes more reliable but also very elaborate in design and complex in construction. In the third stage an effective device results. The period under review brings us to the beginning of that final stage as applied to the rock drill. The Ingersoll and Rand drills were produced in 1870. Ten years later the Holman went to work in the Cornish mines, to be followed shortly afterwards by the Stephens (Climax). The Ingersoll later amalgamated with the Rand; and that firm, together with the Holman and Climax Companies, remain amongst the principal rock drill manufacturers of the world to-day. Many others appeared about this time but have long since disappeared.

Machine mining spread with great rapidity, as the speed of drilling was three to four times higher than by hand and about the same cost per foot. It relieved men of the strenuous labour of beating a 'borer' steel by hand-swung sledge hammers (Plates III, XIX, and XXVIII). Compressed air from the rock drills improved the ventilation, and the expansion of the air helped to reduce the ambient temperature. Men could work in places which were quite impossible before, but this was probably a double-edged advantage, from a miner's health standpoint. The types of rock drills are shown in Plates VII, VIII, IX, XX.

The earliest in this period used no water at all. The first introduction of it was that thrown from a puddle by a small tin (Plate XI). The first real step forward was made when the spray was introduced at

about the turn of the century. This was an important improvement (Plate XII). Often the men neglected to use it, the claim they made being that they would as soon die of phthisis as of pneumonia and rheumatism. The miner had to work closely with his machine, and as the spray made a wide discharge of water it was difficult if not impossible to keep dry.

A culprit amongst the rock drills was the air-feed stoping machine in its hand-rotated model (Plate XXIX). As the holes drilled were upwards the miner was covered in dust when drilling dry and in muddy water when drilling wet with the spray. The machine had to be continuously rotated to and fro by the hand lever to maintain a round hole. This form of drill was commonly called by miners 'the widow maker.' During the next period, the machine became automatic in action and as free from dust as any other (Plate XXX).

Mention was made above of the great emigration of miners from Cornwall. As a result of the appalling health conditions under which they were compelled to work overseas many hundreds returned to Cornwall every year to die of 'miners' complaint.' The pallid face and the hard, short cough was a well-known sight and sound in the Cornish towns.

During the worst period on the Witwatersrand in the first few years after the Boer War it was estimated that the length of active life of a miner was from 3 to 5 years. The record of those days and the subsequent improvement is fully set out in the book printed at the Government Press in Pretoria in June 1937 under the title of 'The Prevention of Silicosis on the Mines of the Witwatersrand.' It is therein shown that of the 60 years of mining there, there was some recognition of silicosis for nearly 50.

No serious notice was taken of the dust hazard until 1902. By that time it had become most grave. All drilling was done by European miners, who remained continuously on the mines and did not go home from time to time to kraals on the open Veldt, as did the natives who were used as spanner boys first and as drill runners later.

The number of rock drills at work was rising rapidly; by 1896 over 1,000 were in use, and the figure had risen by 1899 to over 2,000. Blasting took place at any time during the shift, and all broken rock was shovelled dry. In 1902 a report from the Government Mining Engineer drew attention to what was happening. He said that of 1,177 rock drill men employed on the Rand before the Boer War, 225 were known to have died of phthisis. Even up to 1937, 70 per cent of silicosis on the Rand occurred in men who had been employed on machines. The Miners' Phthisis Commission, which sat in 1903, strongly advocated that water should be used and that ventilation should be improved. It was not for many years that these recommendations were given real effect.

Period V.—1912 to 1945

Rock Drills.—During this period the problem of silicosis was taken firmly in hand, first in South Africa and then later in practically all countries of the world. A great advance was made in the prevention of the formation of dust during drilling operations by the introduction of the Leyner Drill. John George Leyner, of whom a photograph is given in Plate XIII, was the outstanding mechanical genius of the Rock Drill Industry. Almost every drilling machine working to-day operates under the principles which he introduced. Earlier machines used a piston reciprocating in a cylinder having a piston rod projecting through the cylinder cover. The drilling steel was secured in a chuck attachment on the end of the piston rod. Thus, as the piston reciprocated the drill steel was thrust forward to strike a blow on the rock face and then withdrawn in preparation for the next blow. The hole was started with a drill steel of about 2 ft. in length, which was replaced by longer steels as the depth of the hole increased. The normal depth drilled was 6 ft. The diameter of the cutting edge was reduced in each succeeding steel to obtain the necessary clearance. It will be appreciated that a large weight had to be reciprocated at every blow, and thus the number of blows per minute rarely exceeded two or three hundred. The weight of the drill itself was about 350 lb. Leyner brought to practical success the hammer drill principle, which had been experimented with before his day. In this design the drill steel is held loosely in a chuck attached to the cylinder itself, and a piston inside the cylinder reciprocates freely and strikes the blows on the end of the drill steel. A much higher rate of striking, of the order of 1,500 blows per minute, is obtained. A lighter rock drill becomes possible, and the friction caused by the reciprocation of the drill steel in the hole being drilled is avoided. An advantage of the reciprocating principle was that the steel on its return stroke tended to throw out dust and chips of rock from the hole. The stationary drill steel of the hammer principle did not do this.

(Note: A study of plates Nos. VII and XV will show the difference in general construction.)

Leyner was born on his father's ranch in Left Hand Canyon, Boulder County, Colorado, on August 26, 1860 (*Compressed Air Magazine*). His father, of German descent, was a native of Dachenheim,

PLATE XI.—Early method of introducing water into hole.

PLATE XII.—Rock drill of 1902 with spray—drifting.

PLATE XIII.—J. G. Leyner.

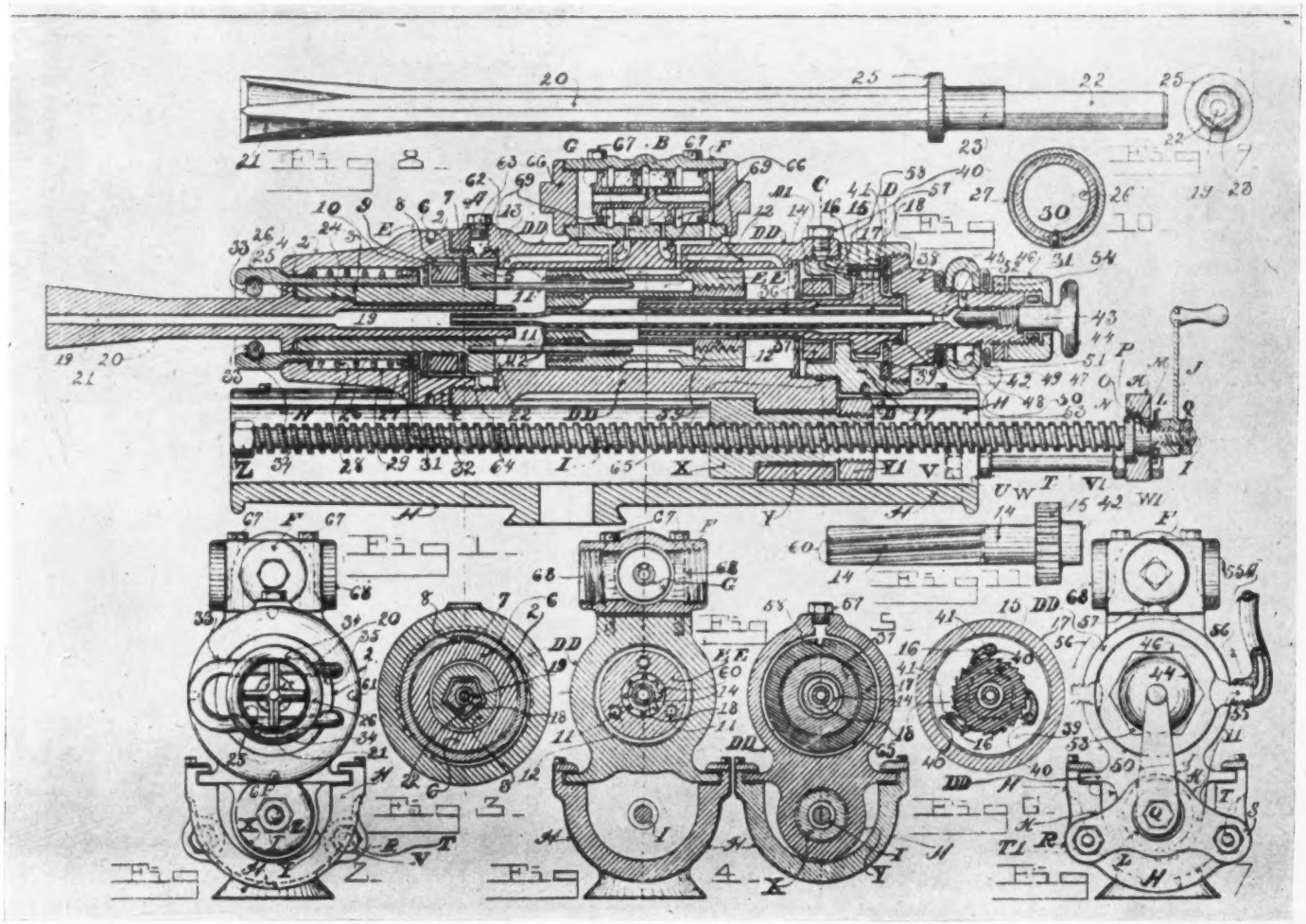


PLATE XIV.—Leyner's first patent.

Germany. His mother came from Dutch stock and was born in Pennsylvania. John George was the eldest of seven children. He attended rural public schools and spent the rest of his boyhood years working on the family farm. The only phase of farming that interested him was the limited mechanical equipment that was then in use, and it was but natural that he should turn to pursuits more to his liking. In 1883 he obtained engineering employment with the Jackson Mining and Milling Company at Black Hawk, Colorado, one of the boom camps of Colorado's gold-mining industry. In 1891 he acquired a small machine shop and foundry in Denver, Colorado. As it was devoted chiefly to the repairing of mining machinery, it was undoubtedly there that he laid the groundwork for his later activities. Rock drills held great interest for him from the start, and he began suggesting improvements on existing models that came into the shop for repairs. After two years, in 1893, he designed a piston drill and began manufacturing it. Although the drill was similar to others on the market, it met with considerable success, for in 1894 Leyner moved to larger quarters. Shortly afterward —the exact time is not known—he began developing a hammer drill. Meanwhile his piston drill continued to be popular.

The few drawings of Leyner's first hammer drills that are still available indicate that his ideas were well crystallized by 1896 and departed considerably from the prevailing practice. He discarded the rifle-bar rotation that was used on piston drills, but subsequently had to revert to it. By the early part of 1897 his drill had reached the point where he decided to put it on the market. He sold about 75 of them, all of which were designed to blow a blast of air through a hollow or channeled drill steel for removing rock cuttings from the hole. After these drills had been in use a short time, workmen refused to run them because they raised so much dust. As Leyner had guaranteed them, he took them back even though it was a financial blow that put him on the verge of bankruptcy. He was convinced, however, that he was on the right track and would not admit defeat. He set to work to find a solution of the dust problem, and finally decided to pass water along with air through the drill steel. The drills were modified accordingly and returned to the field. As the water allayed the dust, there were no further complaints, and the new drills quickly began to show their superiority over other existing types. Leyner obtained a patent on the commingling of air and water in the drill steel; and this patent later proved to be his most valuable asset (Plate XIV). His drills were lighter than piston drills, drilled faster, and were more efficient. In addition, his right to the exclusive use of air and water for removing cuttings from the hole gave him a tremendous advantage over any competitors that also produced a hammer-type machine.

It is impossible to-day for one to appreciate fully the difficulties Leyner encountered in connexion with the introduction of his new type of drill. All drill steel previously employed had been of the solid-bar type. In order to make this drill useful, it was necessary for Leyner to incorporate in the drill steel a tube or hole of some sort through which air and water could be passed. As no method of manufacturing hollow drill steel was then known, all sorts of schemes were tried. Not only Leyner but numerous others attempted to find a satisfactory solution of the problem. He prepared drawings and specifications for such steel in 1898, but none of the mills would make it for him. Thereupon Leyner began to manufacture his own hollow drill steel. He machined bits and forged shanks out of tool steel, drilled a hole through them, and, after scarfing the ends, welded them to the opposite ends of a length of staybolt iron. The result was a composite member with a central hole through it that accomplished the desired purpose, and Leyner continued to make steel in this manner for more than ten years. One of his former employees recalls that after one man had welded on the two end pieces another man would attempt to break them off with a sledge hammer. If they remained intact the steel passed inspection and was shipped.

In 1902 his business had again outgrown its quarters and had attained such a size that Leyner decided to incorporate it under the name of the J. George Leyner Engineering Works Company. At this time the concern was building two models of the 'Water Leyner' drill—the 5A and the 5B. Leyner had discontinued making piston drills in 1900, having become convinced that the hammer drill was the better type. Leyner continued to turn out new models of his drifter drills from time to time, and in 1910 was offering Nos. 7, 8, and 9 to the trade. They were all similar in design and differed only in weight. He had also developed a line of stoping drills. The Leyner drills of that day would not compare favourably with corresponding types built to-day, but then they were the most efficient units obtainable and represented a distinct advance over the piston-type drills.

In 1912 the Leyner Company entered into an agreement with Ingersoll-Rand Company whereby the latter became the sole distributor of Leyner products and was granted the exclusive right to build rock drills under Leyner's patents (Plate XV).

PLATE XIV.—Leyner's first patent.

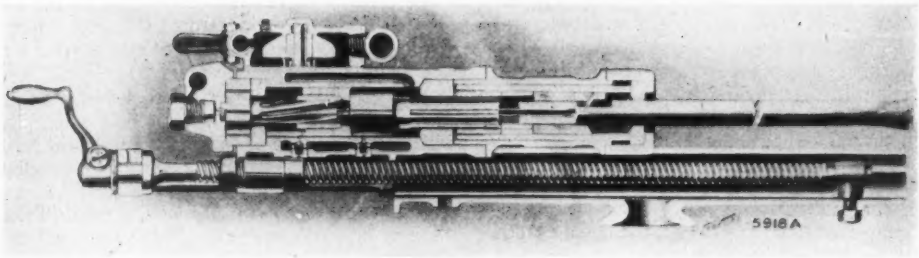


PLATE XV.—Sectional view of Leyner-Ingersoll drifter drill of 1912.

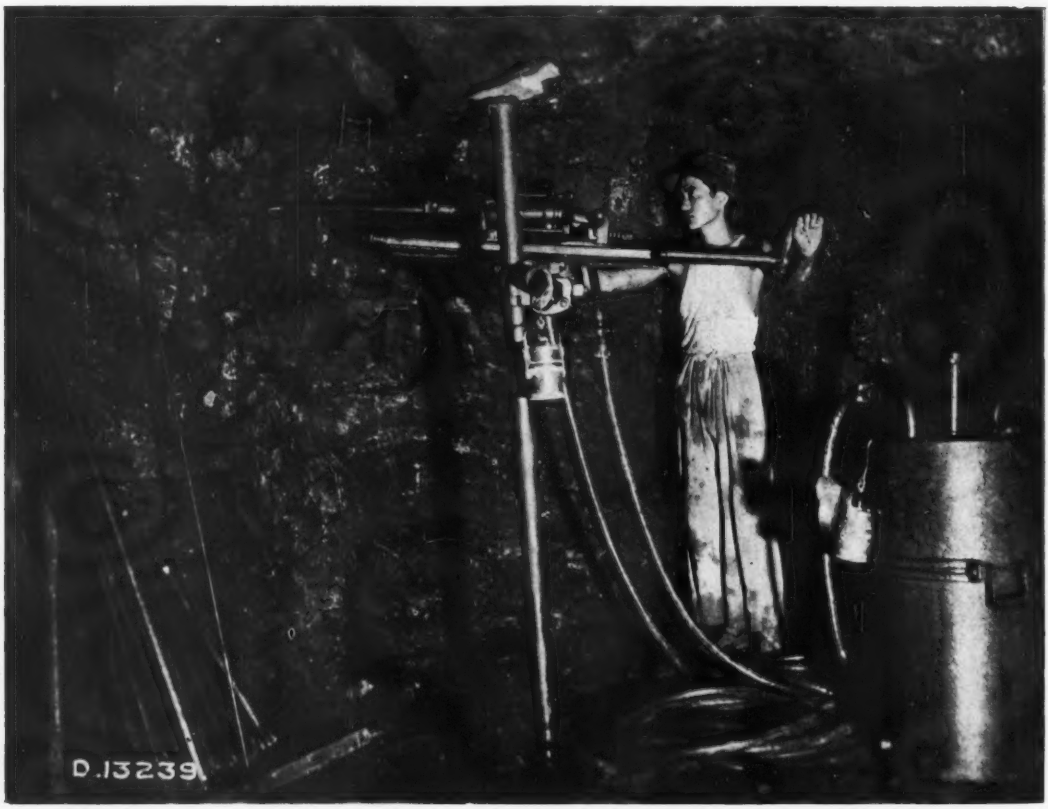


PLATE XVI.—Cradle-mounted hand drill drifting in a Malayan mine. (Note tank for supplying water under pressure.)

LATE XVII.—Vented drifter drill of 1937

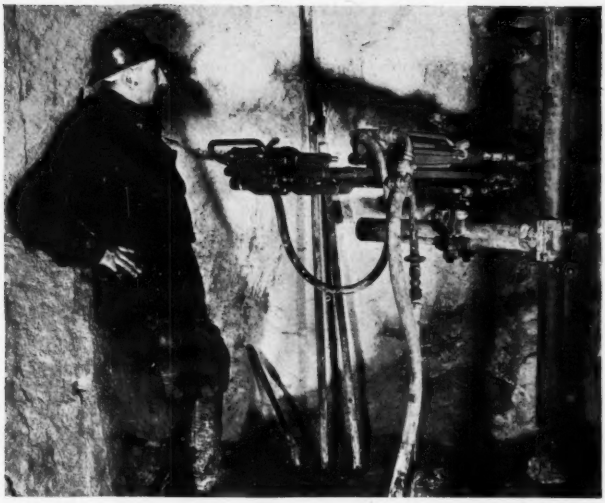


PLATE XVIII.—Automatic vented drifter drill of 1945 with single control for air and water.

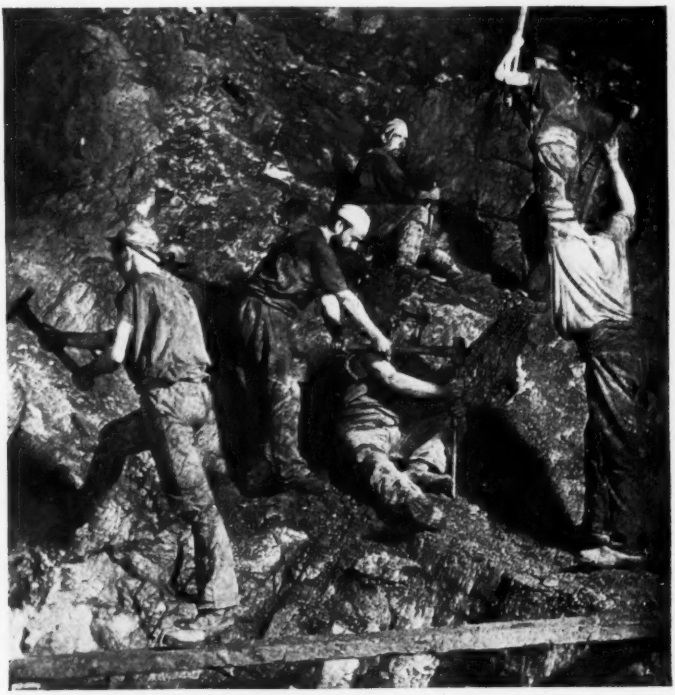


PLATE XIX.—Hand drilling underhand stoping.

On August 3, 1920, Leyner was injured in a motor-car accident, and died two days later, on August 5, three weeks before attaining the age of 60.

In 1913 the Leyner patents covering water through the hollow tube and so through the hollow drill steel terminated, and thereafter this type of rock drill became, by degrees, standard in all mining countries of the world. Although the Leyner drill caused a great reduction in dust, yet it will be noted that in his patents—and his drills followed the patents—water and air passed down the drill steel, the assumption no doubt being that water would not keep the hole clear of itself. It is interesting to note that all other rock drill manufacturers imagined the same thing and, therefore, were unable to use the water tube with hollow drill steel. The modern vented machine as it is made to-day would have been as free from the Leyner patents as it undoubtedly is freer from the making of dust. As will be shown later, no air may pass down the drill steel under recent regulations and so the danger of bubbles containing grains of dry dust being released into the atmosphere is eliminated.

As the story of dust preventive measures is principally laid on the Witwatersrand, we will return to a further consideration of the South African Government publication of 1937. In 1919 the Phthisis Prevention Committee laid down that dry drilling should be prohibited, only axial water-feed (Leyner type) drills to be allowed in raising and box-holing. Other drills must have a water pipe in the hole, the working places must be wetted down from a distance of at least twenty-five feet from the hole. In 1921 there was a total prohibition of drills designed to pass air only down the steel, no matter in which part of the mine they were used. This regulation resulted from research, which showed that the amount of dust liberated by the drills varied almost directly with the amount of air going down the hollow steel. In 1926 a further advance was made, by the prohibition of the use of machine drills having internal water tubes without release ports being provided in the front head of the drill. In 2·5/8-in. cylinder diameter drills, the normal standard, the minimum area of the release ports must be not less than 0·3 of square inch (Plates XXIV and XXV).

The Regulations as they were amended to August 1944 are as follows:

'(1) in drilling a hole no person shall use or cause or permit to be used any percussion machine drill unless

(*a*) the drill steel with which the machine is equipped is provided with an axial hole not less than one-quarter of an inch in diameter throughout its whole length when the diameter of the drill steel is one and one-eighth inch in diameter or over, and not less than three-sixteenths of an inch in diameter throughout its whole length when the diameter of the drill steel is less than one and one-eighth inch; and

(*b*) an adequate supply of water flows through such drill steel; and

(*c*) the working water pressure at the machine drill is maintained at fifteen pounds per square inch or over;

(2) no branch hose or branch pipe shall be fitted to any hose supplying water to any percussion machine drill;

(3) no person shall send or cause or permit to be sent underground any percussion machine drill which is designed to supply water to the drill steel through an internal water tube unless

(*a*) such machine is provided with front-head air release ports of a design approved by the Government Mining Engineer; and

(*b*) the diameter of the axial hole in the piston, when new, does not exceed 0·262 inch and is not less than 0·260 inch for a length of at least two and one-half inches; and

(*c*) the external diameter of the water tube, when new, is not less than 0·255 inch, and the internal diameter of the water tube is not less than 0·156 inch; and

(*d*) the machine drill is fitted with a water tube of such length that, when drill steel of the type supplied for use with the said drill underground is inserted into the chuck to its fullest extent, when the machine is not operating, the water tube either enters the axial hole in the shank of the drill steel for a distance of at least one inch or, alternatively, the end of the water tube is not less than one-quarter of an inch and not more than one inch short of the shank end of the drill steel;

(4) (*a*) no person shall block or otherwise obstruct any of the front-head release ports provided in terms of paragraph (*a*) of sub-regulation (3) of this regulation, and no person shall operate or cause or permit the operation of any machine drill if the front head release ports so provided are partially or totally blocked or otherwise obstructed;

(*b*) no person shall supply for use in, or fit into, any rock drill a water tube which does not comply with the provisions of paragraphs (*c*) and (*d*) of sub-regulation (3) of this regulation;

(*c*) no person shall wilfully damage or alter a water tube supplied for use in a machine drill;

(*d*) any ganger in charge of drilling operations, who knows or has reason to suspect that the water tube in any machine drill under his control has become damaged or is defective, shall immediately examine such water tube and if it is found to be damaged or defective he shall replace it with an undamaged water tube before drilling operations are resumed with any such machine drill. It shall be the duty of any person who knows or has reason to suspect that the water tube in a machine drill is damaged or defective to report the matter immediately to the ganger responsible for the operation of the machine drill;

(5) (*a*) no new type or make of machine drill may be used without the prior approval of the Govern-

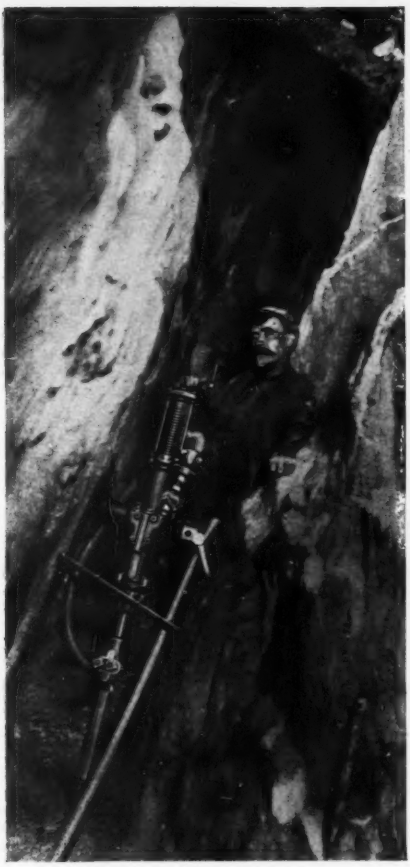


PLATE XX.—Drill of 1905 at work in narrow underhand stope (dry).

PLATE XXI.—Dry drilling in rock.

PLATE XXII.—
Dry drilling in coal.

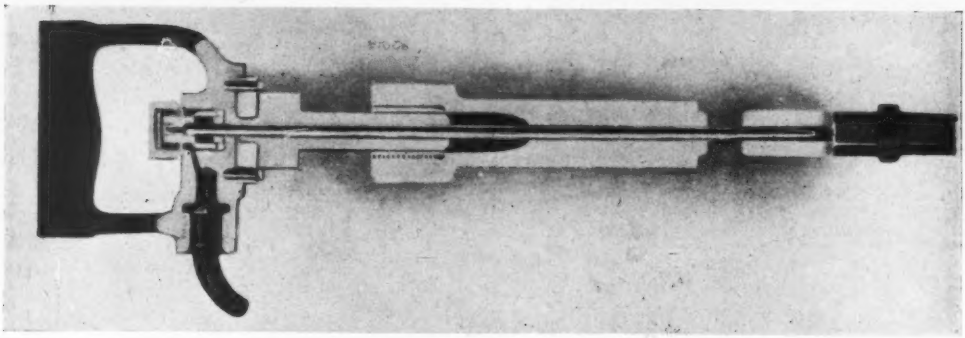


PLATE XXIII.—Water tube assembly, hand-held drill.

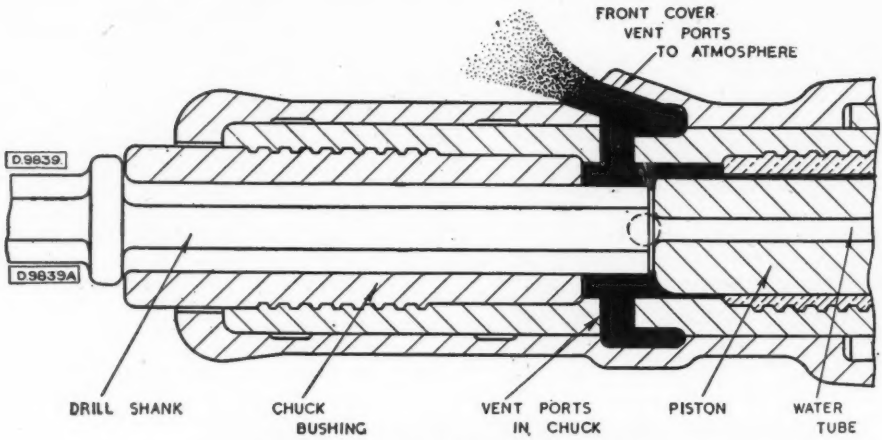


PLATE XXIV.—Modern vented front head.

ment Mining Engineer, or may be continued in use unless that approval is ratified by him within one year, or such longer period as he may determine, and after at least twenty (20) of the machine drills so provisionally approved have been in regular use on scheduled mines, or mines to which this sub-regulation has been applied in terms of sub-regulation (2) of regulation 166, to his knowledge for a period of six months;

(*b*) the Government Mining Engineer may prohibit the use of any type or make of machine drill in use on any scheduled mine. Such prohibition shall take effect after a date to be specified by the Government Mining Engineer, such date to be not less than six months after the date of notice of prohibition;

(*c*) the Government Mining Engineer shall not prohibit the use of any drill under paragraph (*b*) of this sub-regulation unless there is evidence that the drill to be prohibited seriously and materially endangers the health of workmen and until he has consulted the employers and the workmen concerned.

(*d*) the Government Mining Engineer may carry out any inspection or test of any machine drill, device, or attachment at a cost to the owner, manufacturer, or agent of a sum not exceeding thirty pounds (£30) for each complete test:

(*e*) any employer and any owner or manufacturer of a machine drill or his agent may appeal to the Minister against any refusal by the Government Mining Engineer to approve or to ratify the approval of a new type or make of machine drill, or against any prohibition by him of any existing type or make of machine drill, and the decision of the Minister shall be final and conclusive;

(6) no person shall use or cause or permit to be used any hand-drill, moil or similar tool, except in sampling,

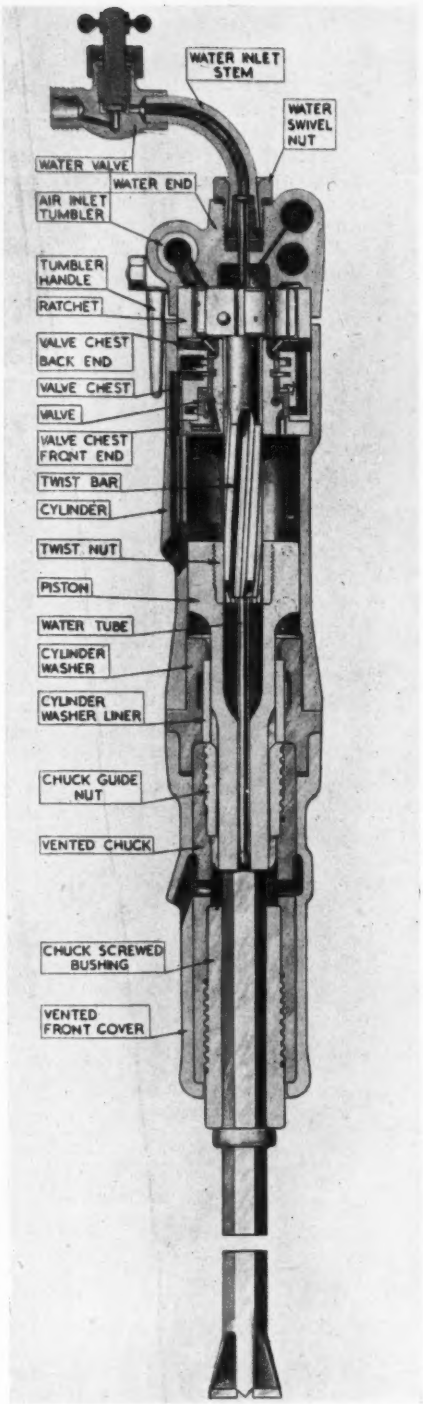


PLATE XXV.—Section of latest vented hand hammer drill (South African pattern) for underhand stoping.

PLATE XXVI.—External view of vented drill of Plate XXV.

unless water is applied or a wet swab is used around the drill at the collar of the hole so as to allay the dust;

(7) (*a*) no person shall commence or continue to drill any hole, or cause or permit such commencement or continuation of drilling unless the floor, roof, sides, packs, other surfaces, and broken rock of the working place, to a distance of at least twenty-five (25) feet from such hole, have been thoroughly wetted and kept wet;
(*b*) no person shall blow out or be caused or permitted to blow out any hole with compressed air unless he has applied sufficient water, in case there is not already a sufficiency, to prevent the formation of dust during the process of blowing out;

(8) no person shall move any broken rock or ground or cause or allow the same to be removed, if such rock or ground is in a dusty condition, unless and until it and the floor, roof and sides, packs and other surfaces of the working place to a distance of at least twenty-five (25) feet have been effectively wetted and kept wet so as to prevent the escape of dust into the air during removal;

(9) no person shall perform or cause or permit to be performed work of any kind liable to create dust unless and until the floor, roof and sides, packs and other surfaces of the working place to a distance of at least twenty-five (25) feet have been effectively wetted and kept wet, unless such working place is naturally sufficiently wet to render the formation of dust impossible;

(10) no person shall negligently cause or permit water supplied from any service pipe for dust-laying or drinking purposes to run to waste;

(11) no person shall use or cause or permit to be used compressed air for cleaning
(*a*) any skip or truck underground;
(*b*) any skip at a downcast shaft at any point lower than the tip in the headgear;
(*c*) the footwall of any stope in the course of sweeping operations.'

In addition to these regulations the quality of water supplied has been investigated. If the water contains solids in suspension, any spray or fog produced by the machine may add dust to the air. Water filtering plants of sand filter beds have been installed in some mines, and a substantial reduction in the dust produced during drilling is claimed.

Silicosis.—As regards the medical aspect, the 1937 South African publication states that much investigation has been carried out and the relationship of silicosis to tuberculosis has been considered in some detail in the light of the experience of the past twenty-five years. The fact of the occurrence of a simple silicosis is upheld. The distinction between a silicosis of simple type and a silicosis of infective type originally based upon clinical and pathological grounds has recently obtained interesting confirmation in the following connexion. In the past few years a good deal of work has been published reporting on the recovery of mineral residues from the lungs of those who have died of pneumonoconiosis, and most observers report that they have found no precise relation between the pathological reaction and the amount of mineral residue recovered. It is clear from the descriptions that much of their material was what would have been called silicosis of infective type. South African experience has been that in the case of simple silicosis 'the degree of reaction is in general proportion to and is limited by the amount of siliceous dust retained in the affected lung.' In the case of silicosis of infective type, including 'tuberculo-silicosis' there is no close relation between extent of lesion and amount of mineral residue covered. This, after all, is what any pathologist would expect. The report states: 'We are satisfied that we meet with a type having a direct relation between mineral residue and extent of lesions which has the clinical and post-mortem characteristics of a simple silicosis, and also with a type exhibiting no such close relation, which has the clinical and post-mortem characteristics of a silicosis of infective type.'

In conformity with these conclusions a brief account is given of the general characters which serve to distinguish the three clinical and pathological types of silicosis met with, namely:

(1) 'Silicosis of simple type' in which the condition present is, apart from the accompanying bronchitis, practically that of a simple nodular dust fibrosis which has undergone no significant modification by infection.

(2) 'Silicosis of infective type' in which lesions of the mixed silicotic and infective characters referred to form a prominent feature, but in which there is no evidence of the presence of active tuberculosis, and

(3) 'Silicosis with tuberculosis' in which a silicotic condition is associated with active tuberculosis.

Finally, it is shown that, when taken as a whole, the prevalent form of silicosis met with nowadays presents three general characteristics:

It is a condition which on the average in those who contract it requires for its production a cumulative duration of some 17 years' previous exposure to our underground conditions.

It remains on the average intrinsically a progressive condition, although the data presented indicate that a gradual amelioration is taking place in this respect and that a considerable number of cases undergo a virtual arrest for prolonged or apparently indefinite periods.

It is, nevertheless, on the average a chronic disease. Some years ago the average expectation of life for all cases from the detection of early silicosis was found to be from 15 to 16 years. It is probably greater now. The average age at which the presence of silicosis is now detected is practically fifty years.

The medico-legal stages of silicosis recognized for purposes of compensation are the following:

(1) 'Ante-primary silicosis,' the earliest detectable stage of the disease in which disability is at most slight and may be absent.

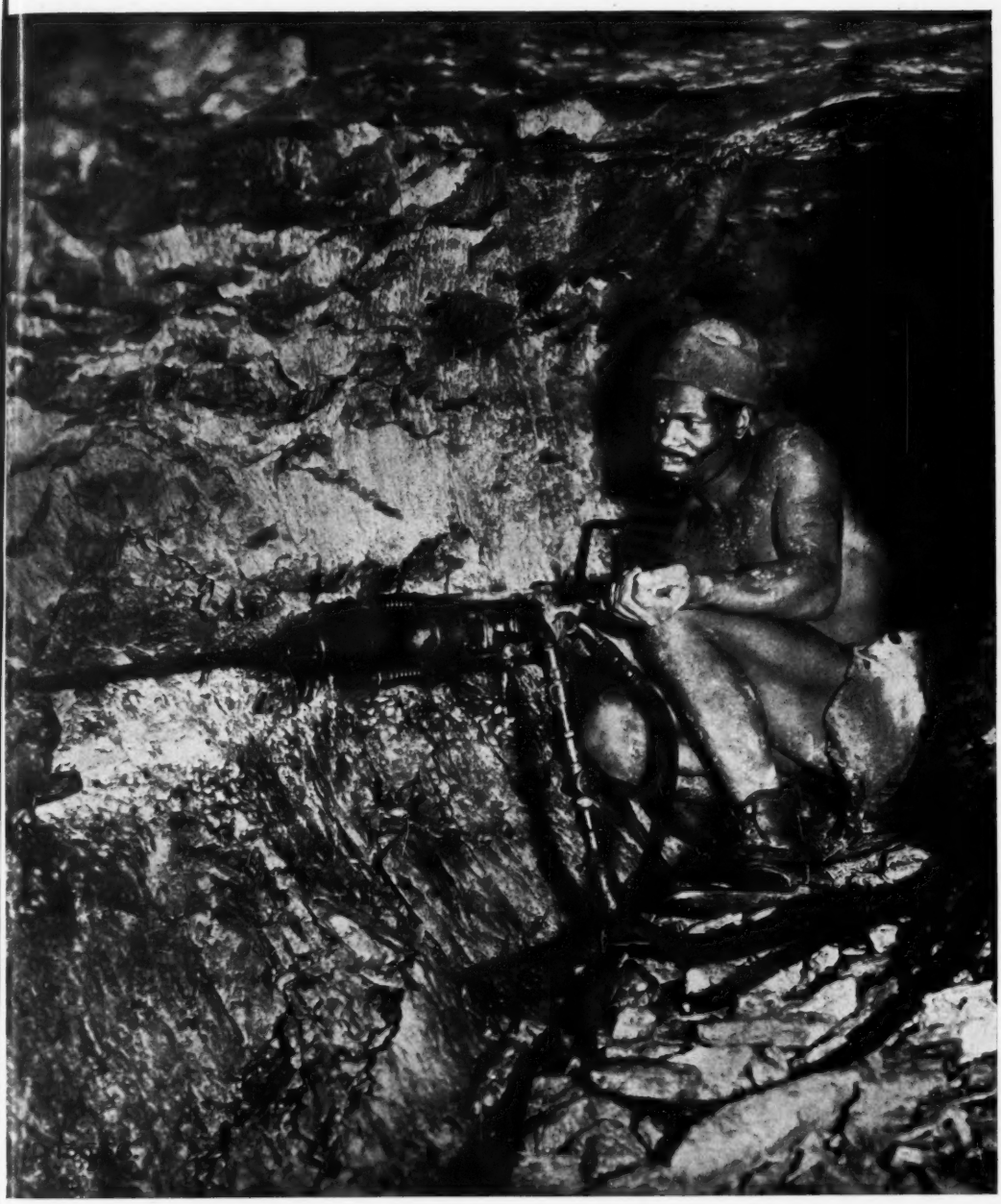


PLATE XXVII.—Underhand stoping on Witwatersrand with vented drill (note air and water hoses).

(2) ' Primary silicosis ' in which there is a moderate degree of disability.

(3) ' Secondary silicosis.' This stage includes cases of silicosis with grave disability and also all cases of ' tuberculosis with silicosis ' in which active tuberculosis is present along with any degree of silicosis.

Before 1919 the earliest compensatable stage of silicosis was the ' primary stage,' in which a miner had to present evidence of disability before qualifying for compensation. This provision was dropped in the Act of 1919. It was not suited to circumstances in which it was the object to detect a chronic disease at a sufficiently early stage for there to be hope of its arrest. Accordingly, in that year the earliest compensatable stage recognized was the ' ante-primary stage ' which was defined as the earliest detectable stage of the disease, irrespective of whether disability was or was not present. The hope that silicosis at this stage would be arrested in the absence of further exposure to dust has not been borne out. Witwatersrand silicosis is, with the qualification previously mentioned, still in the main a progressive condition. Even cases of simple silicosis are progressive up to a point and often to a very considerable degree; further sustained progression signifies infection.

It is the duty of the Miners' Phthisis Medical Bureau to carry out a systematic follow-up of all cases certified up to the stage of grave incapacitation, in order to detect any alteration in their condition which may be significant in respect of compensation. The returns of the Bureau enable one to follow the incidence rates of silicosis from 1917–18 to the present date, a period of twenty years. It is shown that whereas in the period 1917–20 the combined incidence of new cases of silicosis, and silicosis with tuberculosis, detected at the periodical examinations of working miners was 28 per 1,000, in 1920–23 it was approximately 21 per 1,000, and during the past three years has averaged 9 per 1,000. It is pointed out, however, that owing to changes in the medical standard of certification during the first half of the twenty years' period, caused in part by the introduction of compensation for the ante-primary stage in 1919, and in part by a slight further liberalization of the standard of diagnosis effected by the Bureau from 1923 to 1926 as the result of accumulated experience and improved radiographic technique, the incidence rates in these earlier years are not at all points directly comparable with those of the past ten years. The Bureau has, therefore, adopted, as a more accurate comparative measure of the liability of the working miners to contract silicosis at different periods, the method of comparing the incidence of silicosis on miners working in each consecutive year of underground service at the respective different periods. The result is shown in graphs (Plate XXXI) which show very convincingly the decrease in the liability of the working miners to

PLATE XXIX.—Overhand stoper with spray.

PLATE XXVIII.—Hand drilling, overhand stoping.

PLATE XXX.—Automatic overhand stoper with axial water tube : (*a*) control handle ; (*b*) connexion for water hose ; (*c*) connexion for air hose.

contract silicosis at certain selected periods, namely, 1918–20, 1920–23, 1929–32, and 1934–35.

These figures led to the conclusion that the liability of the working miners as a whole was in 1934–35 less by 64 per cent. than it had been in 1920–23, and less, by a figure of the order of 80 per cent., than it had been in 1918–20.

A further graph E is presented showing a similar curve of incidence for the ' New Rand Miners,' i.e. those who have entered the industry since August 1916, by way of the initial examination of the Bureau, and who have worked solely on the Rand. This body represents a group of men of specially selected physical type, who have been exposed solely to the occupational conditions obtaining since 1916, and the measure of silicosis risk of these men is thus of exceptional interest. It is shown that their liability to attack is less by 90 per cent. than it was

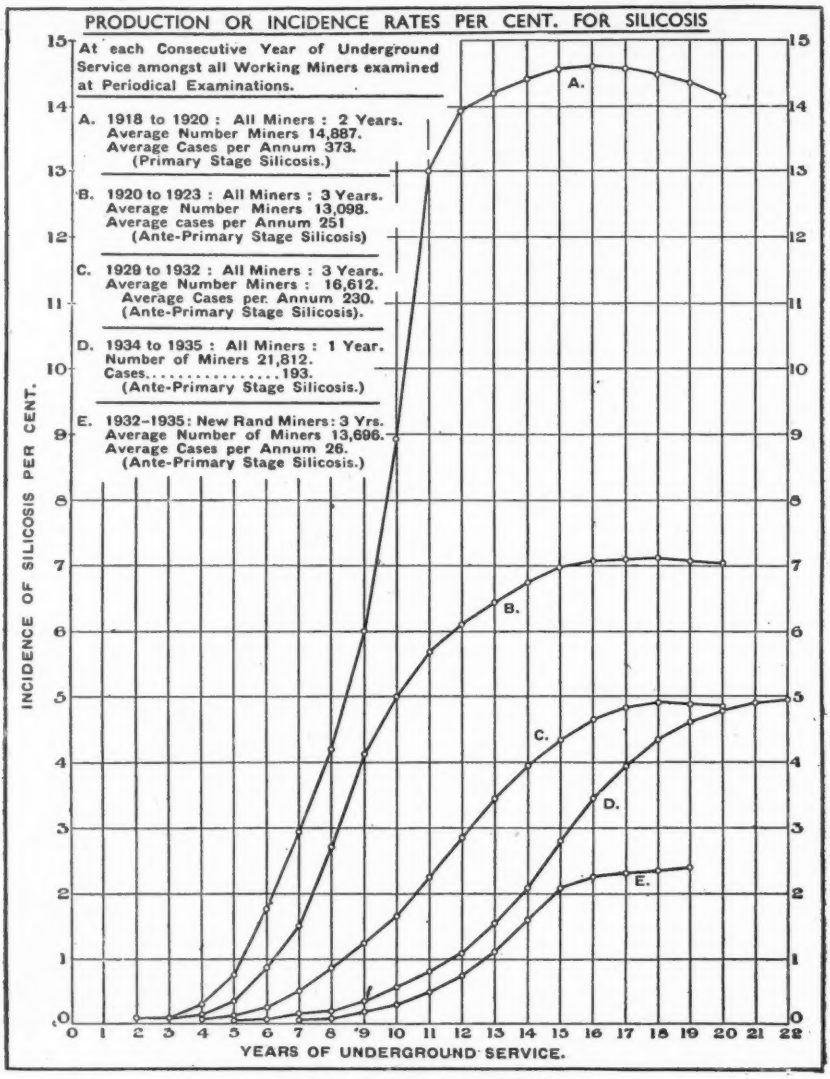

PRODUCTION OR INCIDENCE RATES PER CENT. FOR SILICOSIS
At each Consecutive Year of Underground Service amongst all Working Miners examined at Periodical Examinations.
A. 1918 to 1920 : All Miners : 2 Years. Average Number Miners 14,887. Average Cases per Annum 373. (Primary Stage Silicosis.)
B. 1920 to 1923 : All Miners : 3 Years. Average Number Miners 13,098. Average cases per Annum 251 (Ante-Primary Stage Silicosis)
C. 1929 to 1932 : All Miners : 3 Years. Average Number Miners : 16,612. Average Cases per Annum 230. (Ante-Primary Stage Silicosis).
D. 1934 to 1935 : All Miners : 1 Year. Number of Miners 21,812. Cases.....193. (Ante-Primary Stage Silicosis.)
E. 1932–1935: New Rand Miners: 3 Yrs. Average Number of Miners 13,696. Average Cases per Annum 26. (Ante-Primary Stage Silicosis.)
INCIDENCE OF SILICOSIS PER CENT.
YEARS OF UNDERGROUND SERVICE.

PLATE XXXI.—Graphs of silicosis incidence.

for all miners having an equal duration of service in 1920–23. Nevertheless, it is also shown that even amongst the 'New Rand Miners' the incidence of silicosis amongst those who have had 15 years or more of underground work becomes significant. In spite, therefore, of the very substantial measure of success in the reduction of the incidence of silicosis shown by the Bureau's returns, it is clear that the problem of the prevention of the disease has not yet been completely solved.

The effect of 'good housekeeping' on the Rand is very apparent. There has been an immense reduction in the average concentration of dust in the mine area.

Judging from figures published in 1902 and 1911, the concentration of dust in the mine atmosphere must in the earlier period of the industry have been very high. In the former year figures of 14 to 32 mg. per cubic metre in stopes, and of 192 and 424 mg. in drive faces, are recorded. At the first systematic dust survey of the mines in 1914–15, the general average of the dust content of mine air was at or over 5 mg. per cubic metre; from 1918–20 it was between 2 and 3 mg.; since 1924 it has consistently been approximately 1 mg. or less. This striking achievement of preventive policy has been accompanied not only by the very marked reduction in the liability of the working miner to contract silicosis which has been noted, but by a marked amelioration also in the prevalent type of the disease, by a steady extension of the duration of previous exposure to underground conditions on the part of those who contract silicosis and by a steady rise in the average age of those in whom it is originally detected.

It is emphasized that since the siliceous dust of the Rand is very obviously capable of producing silicosis the important point to determine is in what concentration and in what range of size of particle it is capable of doing so. In this respect it is stated that the evidence gained from size frequency determinations of the mineral dust recovered from silicotic lungs, and of the air-borne dust in the mines, and from experimental evidence, leads to the conclusion that the harm done probably depends chiefly on the number of particles of sizes of 2 or 3 microns and smaller which become lodged in the lungs, and that the practical problem of prevention of silicosis appears to be how siliceous particles of this size range can be prevented from entering mine air or can be removed from it. Silica dust is undoubtedly a chemico-physical irritant, but it is only significant in the production of fibrosis if present in sufficient local concentration, and only facilitates infection by tuberculosis when its concentration is sufficient to have produced or to be capable of producing fibrosis. There is no evidence that the possible passage of dissolved silica into the blood stream produces remote effects on other organs under the conditions of an occupationally acquired dust disease of the lungs. It is recognized that the upward limit of the dust found in silicotic lungs is about 3 microns in greatest dimension, but it has not so far been possible to determine what the downward limit of size of particle which may produce fibrosis under occupational conditions may be, and in what concentration particles at that downward limit must be present. It is reasonable to conclude that the whole size range of the dust retained in the lung is significant, although it is to be expected that the reaction of the smaller particles, within the limits of their potential effect, will be more rapidly attained. It must be borne in mind that the action of siliceous dust in the lung is a cumulative reaction which only becomes significant when a certain local or general concentration of dust has been reached.

The history of this 33-year period shows clearly that immense progress has been made both medically and mechanically towards a solution of the dust problem. The distractions of war slowed down research, and, more particularly, delayed practical application of some of the lessons which had been learnt. With the ending of the war the way was clear for a great tide of improvement; as the next and last period shows, it is now in full flood.

Period VI.—1946 and the Immediate Future

Dust Prevention in Great Britain.—Strict supervision and surface test of underground drills following South African practice is to be introduced into this country. Preliminary regulations have been issued but many months must pass before all the types of rock drills which are being sold are modified to the 'vented' arrangement and have been passed. A serious problem will arise as to the continued use of the many thousands of non-vented drills in operation now. A long-term conversion plan could be achieved by a regulation that replacement parts for worn rock drills should be of the vented type.

It should be noted that vented machines are now being demanded in Rhodesia, West Africa, and elsewhere.

Developments

A number of developments have been introduced in recent years in certain mining fields which are now obtaining wider recognition. They are as follows:

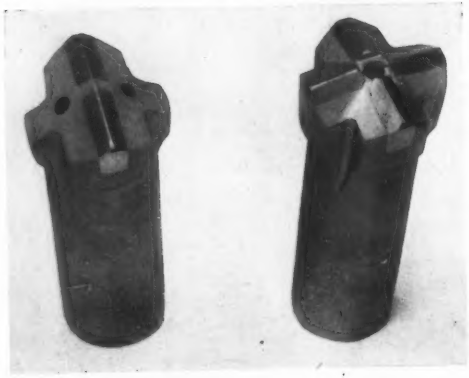
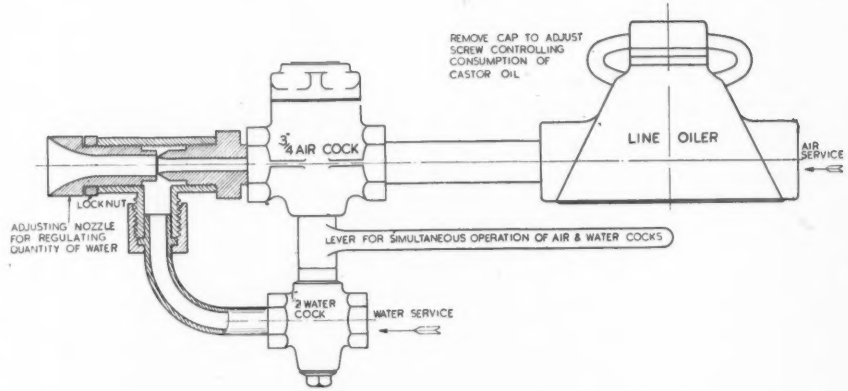


PLATE XXXII.—Tungsten carbide bits.


REMOVE CAP TO ADJUST SCREW CONTROLLING CONSUMPTION OF CASTOR OIL
LINE OILER
AIR SERVICE
3/4 AIR COCK
LOCK NUT
ADJUSTING NOZZLE FOR REGULATING QUANTITY OF WATER
LEVER FOR SIMULTANEOUS OPERATION OF AIR & WATER COCKS
2 WATER COCK
WATER SERVICE

WETHERILL DUST ALLAYING PROJECTOR
PLATE XXXIII.

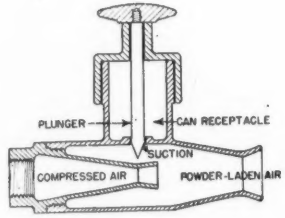


PLATE XXXIV.—Ejector for dispersing aluminium powder.

PLATE XXXV.—Ejector dispersing powder.

Automatic Drifters.—Rock drills of the type shown in Plate XVIII are available since the war which are entirely automatic in action. The water is turned on by the same lever and at the same instant as the compressed air, and the drill then feeds itself forward, and controls its own advance according to the hardness of the ground. When the drill has completed its run, a lever is reversed by hand and the drill retracts itself in readiness for the next drill steel. The operator is relieved from all heavy work and vibration. As the drill steel is guided by a centralizer on starting the hole, it is unnecessary for a man to be near the face whilst the machine is working. Such a drill fully vented to avoid air passing down the steel is virtually free from dust danger. Improvements in mounting these drills have been made to reduce and simplify labour.

Long Piston Hammer Drills.—In the latest form of hand-held drills a longer form of piston rod is being used which reduces the quantity of air which can escape to the vicinity of the chuck. This throws less duty on the venting ports and is an added factor of safety.

Blast-Hole Drilling.—In recent years a form of rotary drilling has been adopted in mines with large ore bodies which makes use of a light type of diamond prospecting drill. A small tube tipped with a diamond-studded crown is pressed into the rock whilst being rotated by an air operated motor. The tube extends rearwardly through the air motor part of the machine and to this end a water connexion is made. The water passes down the tube, cooling the cutting edge and allaying all dust. It is impossible for compressed air to gain access to the tube, and thus the formation of bubbles containing dry dust is prevented. This method of drilling is confined for economic reasons at present to holes of 25 feet in depth and more, owing to the relative slow rate of drilling speed. It is the safest form of drilling so far introduced for the avoidance of dust formation and it may be available later for wider use.

Foam and Wetting Agents.—The South African Report (1937) states that the results of tests with foam instead of water were entirely disappointing, but a more encouraging trial was reported in the 'Colliery Guardian,' April 12, 1946 :

'In the Kent coalfield, with the exception of one colliery, problems of dust suppression have the added urgency of a high and increasing rate of pneumonoconiosis incidence. At Chislet Colliery, where the work submitted in the present paper has been carried out, there is a good deal of hard and highly siliceous rock, containing up to 80 per cent. of free silica, which no doubt accounts for most, if not all, of the respiratory disease encountered; but a study of the percentage incidence among various grades of underground workers suggests that coal dust cannot entirely be exculpated. For that reason, although rock dust suppression has received priority, coal dust suppression has also received close attention in investigations at Chislet.

The addition of foaming agents to drilling water, with the twofold object of increasing the dust suppression efficiency of wet drilling and reducing the quantity of water required, was widely experimented with some ten years ago. It was discarded in most mining districts on account of difficulties experienced.

It was brought to the Colliery Company's notice early in 1946 that, arising from the use of foam on a tremendous scale for war-time fire fighting, an entirely new system of foam production has been devised in which water and reagent are fed to the mixing tube under constant head, with consequent elimination of the difficulties mentioned above.

Initial tests of foam drilling were made in a bed of hard sandstone rock in an old airway approximately 7½ by 6 ft., carrying ventilating current of less than 90 ft./min. The ventilation conditions were thus comparable with those obtaining in a fast heading with auxiliary ventilation. Dust estimation in this and all subsequent drilling tests was by konimeter.

It was clear from the results obtained that the quantity of dust escaping to the general body of the air was negligibly small, but it was observed that, at fairly regular 15 to 20 sec. intervals, a large bubble of air escaped from the foam, and as each bubble burst a momentary haze was seen. On examination with the konimeter the haze was found to consist of a high concentration of extremely fine dust particles.

It was found that when foam was passed through the drilling equipment with the drill itself not in motion, a perfectly uniform stream was obtained, free from interruption of the kind described above, suggesting that the bubbles might be due to compressed air leaking past the piston, penetrating through the chuck and into the flush head.

In order to test this conclusion a new 'silver bullet' machine was taken into use. A vented front cover was fitted in order to prevent leakage through the cylinder building up pressure inside the chuck (Plate XXVI). This assembly was completely successful. Consistency of foam remained unaltered with the machine out of or in operation, and dust-containing bubbles were not formed.

During a full-scale practical trial in a cross-measure drift, 510 7-ft. holes were put in with foam without experiencing any trouble from the foam unit or accessories.'

Tungsten Carbide Bits.—A hard metal edge is now available for tipping drill steels. The edge remains sharp for at least fifty times longer than with ordinary steel, and thus the rock is chipped rather than crushed. The percentage of the finest and most dangerous dust is less. It is claimed by some investigators that the percentage of dust under five microns in diameter is reduced. Confirmation of this point has still to be made by prolonged trials under exact control conditions. The development is worthy of study from this angle. Parallel holes can be drilled with long steels, so reducing the time

factor and the size and weight of drill needed and thus the labour involved. The development will have, in the near future, a very far-reaching effect on all rock-drilling operations. In Plate XXXII a chisel-type bit and a cross bit are shown. The tungsten carbide tip is brazed into a steel body, which in turn is secured to a drill rod of the required length by a tapered insert.

Dust Eductor.—Yet another new development which has distinct possibilities is still in the experimental stage. This is the extraction of the dust created during drilling, through the hollow steel normally used for passing water to the cutting edge.

The eductor system was developed for the Royal Engineers before the war to remove spoil from saps in trench warfare in a silent manner. In the final development small stones, gravel, earth, and sand were educted over 1,000 feet in length to varying heights, and the system was officially adopted. In the present application the coarse dust can be removed by a cyclonic separator and the finest and most dangerous dust transmitted to a safe place for disposal. Under this system no water is required near the working face and thus working conditions can be dry and free from damp.

Wetherill Dust-Allaying Projector.—In 1935 Major A. Hibbert, D.S.O., M.C., and Mr. Charles Wetherill of the Millom and Askam Hematite Iron Co. Ltd., began experiments to allay the dust created by blasting by means of a fog projected into the face being blasted. Water by itself was first tried, but it was found to be useless as it saturated the air and held the dust particles floating, which only settled as the water evaporated. Something clearly was required to brake down the surface tension of the water. After trying various agents, castor-oil was found to answer the purpose most effectively. The form of spray as now developed is shown in Plate XXXIII. Air is supplied to the castor-oil filled line oiler at the ordinary rock drill mains' pressure of 80 lb. per sq. in. It is recommended that the water pressure should be about the same and is normally connected to the mine water service. Adjustments can be made to suit varying pressures. The method of using the spray is to set it up about 30 feet from the face to be blasted; the spray having previously been set to give the necessary fine fog, and the adjustments locked. In cases where electric detonation is used the spray is allowed to operate for three or four minutes before the charge is fired, but where fuse is used they are lit and the miners turn on the spray in passing same on their way out.

One outfit is sufficient for a drive of about 7 ft. by 7 ft. After being in operation for 10 minutes the air is usually free of dust and fumes, and miners can resume operations.

To take a specific case, Florence Mines use these sprays regularly and men restart work at the end of 10 minutes after a blast; without sprays, as much as 40 minutes is taken before men can return, and even then the end is not in comfortable working conditions.

Aluminium Prophylaxis.—It has been observed that certain substances reduce the solubility of silica. Of these substances finely powdered aluminium has proved to be one of the most effective, and Gardner and others (1944) has shown that it is an effective prophylactic in animals. The treatment is now in widespread use in Canada where it originated, in the United States, Australia, and elsewhere. It will

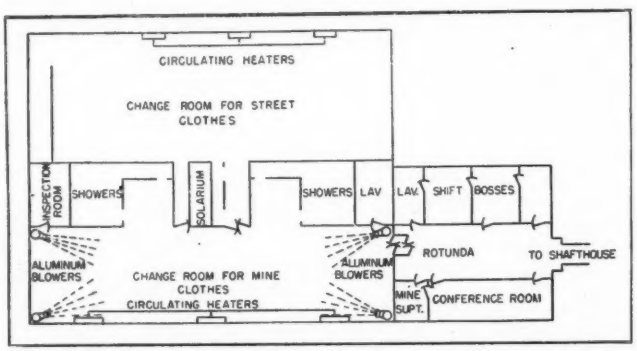


PLATE XXXVI.—Diagram of floor of McIntyre change-house showing the arrangements made for aluminium prophylaxis.

be many years before its value in human silicosis can be assessed ; and it is probable that the engineering developments discussed in this paper are likely to play a much greater part in the suppression of that disease. Nevertheless it is worth recording the technical method of applying this treatment that has been adopted, a full account of which has been given by Jacob (1946). The powder is dispersed into the change room when the men are getting ready to go underground, the room being as airtight as possible. The opening and closing of doors and entry of draughts are avoided, as the suspension of the powder is thereby dissipated. The powder used is 99 per cent. metallic aluminium. For dispersal an ejector operated (Plate XXXIV) by clean, dry, compressed air is used with an air pressure in the pipe line of 100 lb. per sq. inch, the air being turned on quickly and left full on for one minute. A quick-opening tap is used, only one ejector being turned on at one time to avoid loss of particles by impingement (Plate XXXV). The dispersal is completed before the men enter the room, since there is danger from a blast of powder in the eyes. The amount of powder used is 1 g. for each 1,000 cu. ft. of room content based on a ten-minute exposure. If the exposure is twenty minutes the quantity is halved. After the last man has left, the room is cleared by ventilation to avoid the powder blackening the walls. The layout of the McIntyre change-house is shown in Plate XXXVI.

Recommendations

1. The elimination of all dry drilling where dust is permitted to enter the atmosphere.

2. The venting of all drills to prevent air passing down the steel.

3. The elimination of all separate water taps and cocks near the drills so that water must pass down the hollow steel immediately the drill begins work by single lever control.

4. A highly efficient system of ventilation.

5. The lining of all underground passage-ways by cement sprayed from the cement gun.

6. Bright illumination of all working places and passage-ways by electricity.

7. Compulsory use of gloves by all underground workers.

8. Periodic medical examination of all men working underground.

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THE CONTROL AND ELIMINATION OF SILICOSIS IN THE WEST COAST HAEMATITE IRON ORE INDUSTRY*

BY

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Introduction

The history of haematite iron ore mining in the Cumberland and Furness districts has been excellently described by Kendall (1893), and from a summary of this and works by Smith (1924), the following brief facts have been taken.

The date of the first working of haematite in Cumberland and Furness is uncertain, but the exposed veins in the Lake District must have been known long before the concealed bodies were discovered. The Furness ore appears to have been known to the ancient Britons, for, some time ago, polished celts were found in old workings at Stainton. That the Romans worked iron ore in Cumberland and Furness is probable. Numerous heaps of cinders found in Furness have been attributed to the Roman period, but some authorities attribute them to the Norsemen. The earliest account dealing with Cumberland is of mining at Bigrigg in 1179, and at this time a forge was set up, but it was not until the eighteenth century that ore was produced in any quantity, although constant mining was in progress until 1701 at Bigrigg, and even in 1694 the ore was being shipped via Whitehaven to the Forest of Dean. In 1816 mining was almost discontinued, but the Bigrigg mines were re-opened in 1825. From the accounts of Fell (1908), the monks dug their ore from trenches, but towards the end of the fourteenth century mining came into practice. Pumps were installed in 1721, and in 1840 a steam engine was used. The ordinary tools employed by the miner were the pick, the gad, and the spade, which even as late as the first half of the nineteenth century were wooden and shod with iron. The hammer and jumper method was the regulation method of drilling from early times until 1913. In 1913 the pneumatic drill, afterwards known as the dry drill type, was introduced, and was in universal use until about 1925, when the wet drill was first used at Florence Mines, and gradually came into general use in the ore field. Concurrently with the introduction of wet drills, considerable attention was paid to improving ventilation, and exhaust fans were installed. A further technical advance in allaying the dust after blasting was made through the introduction and development of the mist projector in 1935.

Before the introduction of pneumatic drills it was traditionally believed, amongst both laymen and the medical profession, that haematite iron ore mining was a very healthy occupation. After the introduction of pneumatic drills in 1913 all the evils which occurred were attributed to their use. Notwithstanding the tradition, Collis (1923) made the suggestive observations that in 1910 the haematite miners of Cumberland and Lancashire contrasted with all other ironstone miners in the country, in showing not only a higher mortality from phthisis and other pulmonary diseases, but also a maximum mortality from phthisis at a later age period.

Cronin (1926), after an investigation, including the inspection of four mines and the examination and interrogation of 100 drillers, pointed out some highly unsatisfactory features. He drew attention to the dustiness of the working places, and to the frequent lack of ventilation at the working faces. He showed that a percentage of the men became short of breath after working for long periods in the mines, and concluded that the inhalation of haematite dust produces certain changes in the lungs which are diffuse and not localized and which affect the apices more than the bases. He added that ' the changes do not give rise to the pulmonary diseases—i.e. asthma, bronchitis, pneumonia, and phthisis—which commonly result from dust inhalation.' In 1933 the ' Committee on Industrial Pulmonary Disease ' of the Medical Research Council issued a report with the following conclusions:

1. A certain proportion of haematite miners suffer from a form of pneumoconiosis caused by the inhalation of mine dust containing both finely divided haematite and silica. There appears to be a notable pre-

* Based on a paper read to the Association of Industrial Medical Officers at the London School of Hygiene and Tropical Medicine on December 14, 1945.

disposition to the development of tuberculosis, and in some cases the disease causes disablement and death.

2. The disease presents definite characteristics, so that it can be recognized on clinical and radiological grounds during life, and by post-mortem examination of the lungs in fatal cases.
3. There was not sufficient evidence to enable the Committee to say what part, if any, was played by the haematite present in the dust, but, in view of the geological evidence, they considered that silica was invariably present in the mine dust and may be inhaled to such an extent as to cause fibrosis of the lungs. In this connexion it appeared to them to be consistent with the evidence and the present nomenclature to describe the disease as a form of silicosis, that is, fibrosis of the lungs due to silica dust.
4. The evidence pointed to a risk being associated with the employment of machine drilling, but the Committee did not feel that other workers underground, though not so employed, could be regarded as free from risk.
5. Lastly, the Committee, regarding the dust produced in haematite mines as dangerous, recommended that due consideration be given to measures for suppressing the dust in these mines.

When it was realized that there was a risk to health and life in the processes of haematite mining, the management were very soon investigating the facts and considering means of improving conditions. Wet drills had already been introduced into the Florence and Ullcoats mines, and these were soon adopted by other companies. At the same time the manager of the Florence and Ullcoats mines was spending much time and thought on the question of dust suppression after blasting. In 1934 a scheme was conceived for the closest co-operation between mining and medical control in order to improve the health of the industry. The three largest mining concerns formed a small company to control this work, and I was appointed medical director. A house was purchased in Whitehaven and equipped with a large *x*-ray and clinical room with a modern high power *x*-ray plant that can take chest radiographs at a distance of 6 feet and with an exposure of a 1/20th of a second; a large waiting room; a fully equipped laboratory, both clinical and pathological, in which the routine and research studies are carried out; an office and filing room so that consecutive yearly records can be kept of each workman.

In 1935 the Silicosis Act came into being for the haematite iron ore mining industry. The country was still in a state of industrial depression, and there was much under-nourishment in the Egremont district. The managements decided to make examination of all workmen entering the industry compulsory.

The Problems

Three main policies were decided on: (1) the selection of men suitable for work underground; (2) the institution and maintenance of optimum working conditions underground; and (3) medical supervision of selected workmen.

A long-term investigation was also started on the significance and magnitude of the problem of pneumoconiosis.

Estimation of the Hazard

The haematite mines of the north-west coast comprise three separate and distinct groups: (*a*) the Egremont district in West Cumberland, which now extends between Cleator Moor (three miles east of Whitehaven) and Haile (two miles south-east of Egremont); (*b*) the Hodbarrow mines near Millom; and (*c*) the Furness district. The haematite iron ores occur in the carboniferous limestone. The bodies vary in shape and size; the majority are connected with faulting. The mines still operating are working fairly large, irregularly shaped masses.

From the point of view of the incidence of silicosis the ore is of two distinct types. (*a*) Compact, hard, massive, brownish-red or purple to bluish-grey ore, varying considerably in hardness, is the predominating type found in the Egremont district. (*b*) Soft, dull, reddish-purple ore is the main type found in the Hodbarrow mines and Furness district.

The working conditions vary considerably according to the hardness of the ore, which governs the type and use of pneumatic drills, and also the quantity of explosives necessary per ton of ore mined, which in turn is correlated to the amount of dust produced.

By the examination of chemical analysis of haematite ores during the last 50 years, it was ascertained that the better class ores usually contain about 7 per cent. insoluble residues, but this percentage may rise to 20. The washed residue of all haematite ores after the iron has been digested with HCl shows a large preponderance of quartz, with a small amount of amorphous silicate of alumina, and on rare occasions an almost infinitesimal amount of silicate of iron.

Mining Conditions and Radiological Findings in Miners' Lungs before 1935

The mining conditions in most mines before 1935 were characterized by an all-pervading dustiness in the underground workings. Some of the mines, which have now been closed, were undoubtedly badly

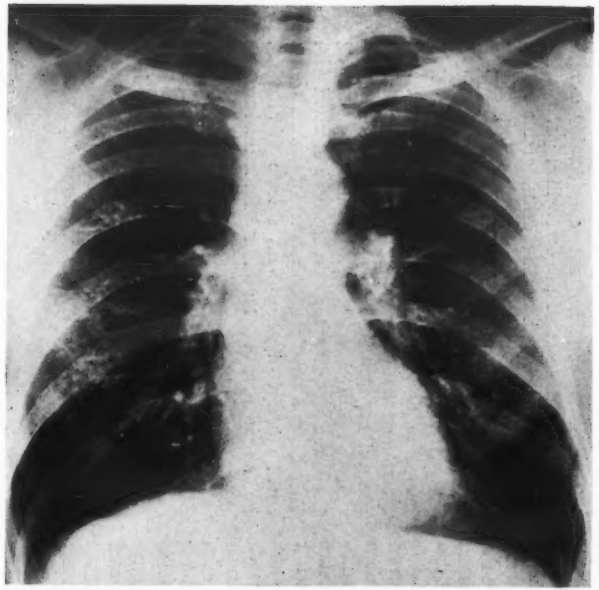

FIG. 1.—A case with marked radiological reticulation. Man aged 48, iron-ore miner for thirty years (twenty-two years in pneumatic drills); no pulmonary symptoms; died from carcinoma of the pancreas.

FIG. 2.—Detail from fig.1, showing the well-established reticulation.

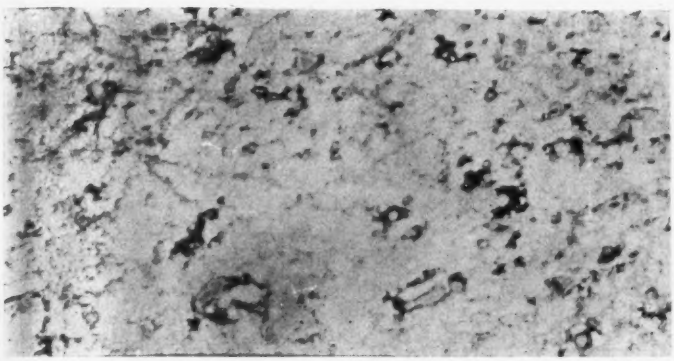

FIG. 3.—Section of the lung shown in fig. 1 ; note the typical appearances of small, irregular-shaped nodules due to linear accumulation of dust. (× 15.)

ventilated, and the temperature at the working face sometimes rose as high as 90° F. Dust was inhaled in large quantities, and the miners were constantly 'hawking and spitting.' On various occasions a dust count specimen taken under the old working conditions revealed particles heaped up on the slide and quite uncountable. The total number of particles must have been many millions per c.cm.

An opportunity presented itself to examine a fairly large group of underground workers who had spent all their working life in haematite mines under the conditions that existed before 1935, but before analysing the findings it is necessary to explain the radiological changes that occur in the lungs of haematite miners as a result of inhaling the dust in which they worked.

Radiological Changes and Pathological Anatomy

Iron casts a very dense radiological shadow, and if haematite is radiographed side by side with an equal bulk of coal dust it is shown to possess 4·5 times the radiological density. This fact should always be remembered in comparing the shadows seen in the radiograph of an iron ore miner's chest and, for example, a coal miner's. With this reservation a classification has been formulated of the same general type as was followed by Hart and others (1942) in their report on

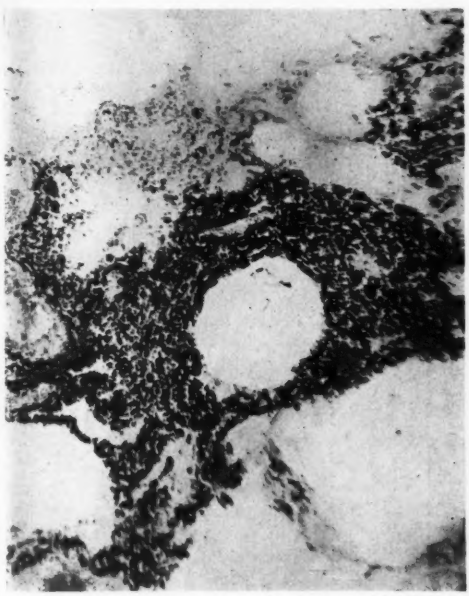

FIG. 4A.—Nodule from the specimen in fig. 3. Ordinary staining.

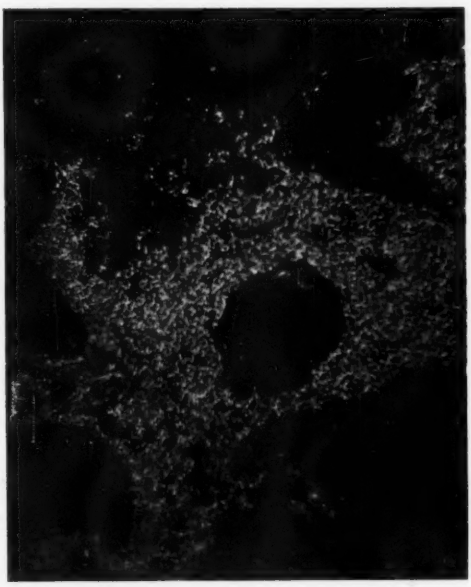

FIG. 4B.—The same section under dark-ground illumination.

FIG. 2.—Detail from fig. 1, showing the well-established reticulation.

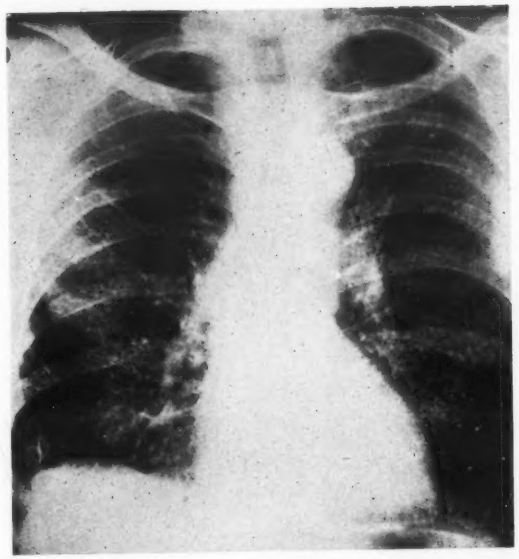

FIG. 5.—Radiograph showing lace markings. Man aged 62 ; iron-ore miner for forty-eight years (twenty years on pneumatic drills) ; no pulmonary symptoms ; died from carcinoma of the stomach.

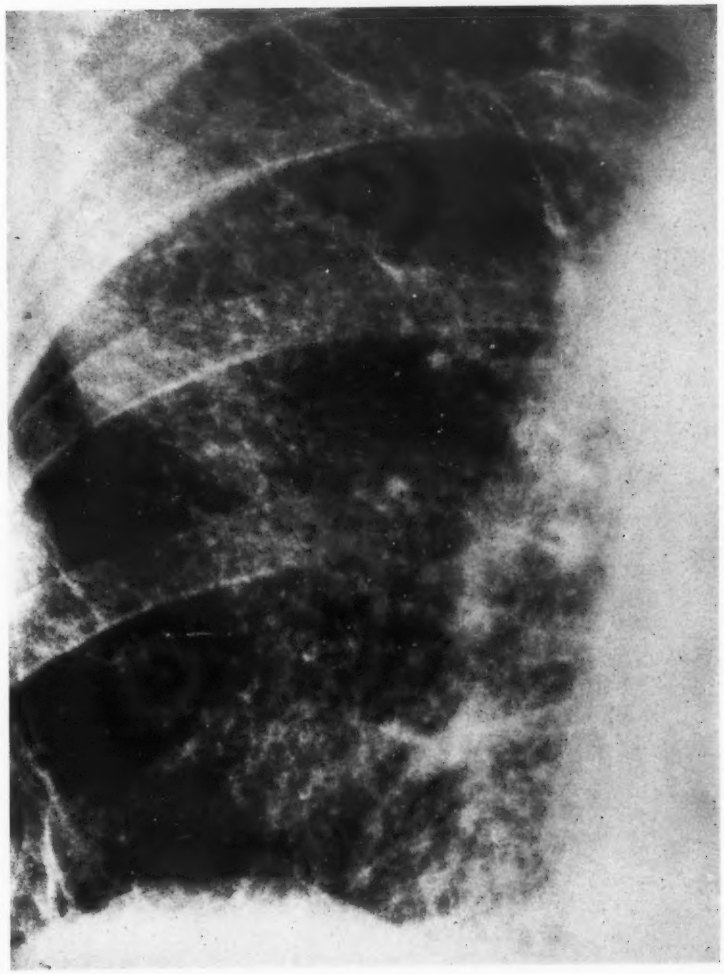

FIG. 6.—Detail from fig. 5.

chronic pulmonary disease in South Wales coal miners.

The following facts are from the findings at necropsies performed in the last 10 years, and show that the *x*-ray shadows conform accurately to the pathological anatomy. It is found convenient to classify the radiological types as follows: (1) normal; (2) exaggerated linear markings; (3) radiological reticulations; (4) radiological nodulation; (5) massive shadows.

2. *Exaggerated Linear Markings.*—The shadows have no differentiating features from numerous other conditions causing exaggeration of the normal vascular markings.

3. *Radiological Reticulation.*—There are two distinct types: (*a*) reticulation proper, and (*b*) lace markings.

(*a*) *Reticulation proper* may vary from exceedingly fine to coarse, and the shadows have a striking resemblance to miliary tuberculosis in its varying phases. Fig. 1 is the radiograph of such a case; fig. 2 is a contact print showing well established radiographic reticulation. The cut surface of the lung is usually a dull brown colour, but may be grey if the amount of dust is not great. No nodulation or linear fibrosis is either palpable or visible, nor is there any nodulation or even firmness palpable or visible under the pleura. Fig. 3 shows an ordinary section (× 15) with the typical appearances of small irregular-shaped nodules about ½ mm. in size due to linear accumulations of dust. All these are in perivascular locations. There is no evidence of collagen formation, and diligent search after Wilder's reticulin stain shows either none or very sparse amount of reticulin fibres. There is plenty of particulate dust, especially haematite. Fig. 4A shows a nodule with ordinary staining, fig. 4B is the same section under dark-ground illumination. These illustrations show that almost the entire structure is particulate haematite and silica. The pathological entity is the same in fine and coarse radiological reticulation, the variation being only in degree.

The chemical analysis of the lung shown in fig. 1 showed: percentage silica to lung 0·95; percentage silica to ash 6·3; percentage Fe_2O_3 to lung 7·7; percentage Fe_2O_3 to ash 50; total silica 2·35 g.

(*b*) *Lace markings.*—This type of radiological reticulation is rare. The shadows are very heavy and dense, giving the appearance of an interwoven linear pattern, the striae being of equal thickness throughout. Fig. 5 is a radiograph from such a case, and Fig. 6 a contact print. Again the cut surface shows no visible or palpable nodulation or other fibrosis—only linear arrangement of the dust with concentrated deposits. Such dust accumulation

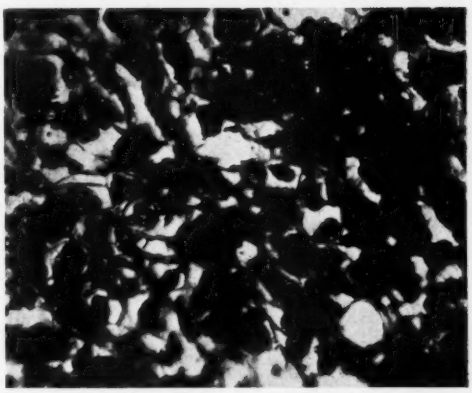

FIG. 7.—Dust accumulation, showing reticulation : same case as fig. 5. Wilder's reticulation stain.

when stained with Wilder's reticulin stain shows definite reticulation (fig. 7). The silica and iron content of this lung was very high.

The chemical analysis of the lung shown in fig. 5 showed: percentage silica to lung 1·9; percentage silica to ash 8; percentage Fe_2O_3 to lung 12; percentage Fe_2O_3 to ash 49; total silica 4·8 g.

3. *Radiological Nodulation.*—Nodulation of a size of about 2 mm. is relatively uncommon when there are no associated conglomerate masses. A certain number do occur, and they are always in association with radiological reticulation. Radiologically the nodules are without clear-cut edges, and the consistency of the shadow varies within the nodule. Fig. 8 shows the radiograph of such a case, and fig. 9 a contact print. The cut surface of the lung is characteristic. The lung substance is either normal or very slightly brown-stained, and dotted over the surface are areas of brownish or reddish-brown nodules. They look and feel slightly raised above the surface, and are slightly more resistant to touch than the intervening lung tissue (fig. 10). Fig. 11 shows a typical nodule (this case died of peritonitis and had a terminal pneumonia). It is seen to have irregular edges and not to be compact. The nodule is formed of particulate silica and haematite enmeshed in sparse immature collagen.

The chemical analysis of the lung shown in fig. 8 showed: percentage silica to lung 1·03; percentage silica to ash 7·2; percentage Fe_2O_3 to lung 6·56; percentage Fe_2O_3 to ash 46.

Pathological Anatomy of Conglomerate Fibrosis

The pathological anatomy of conglomerate fibrosis is similar to the massive fibrosis seen in all

FIG. 6.—Detail from fig. 5.

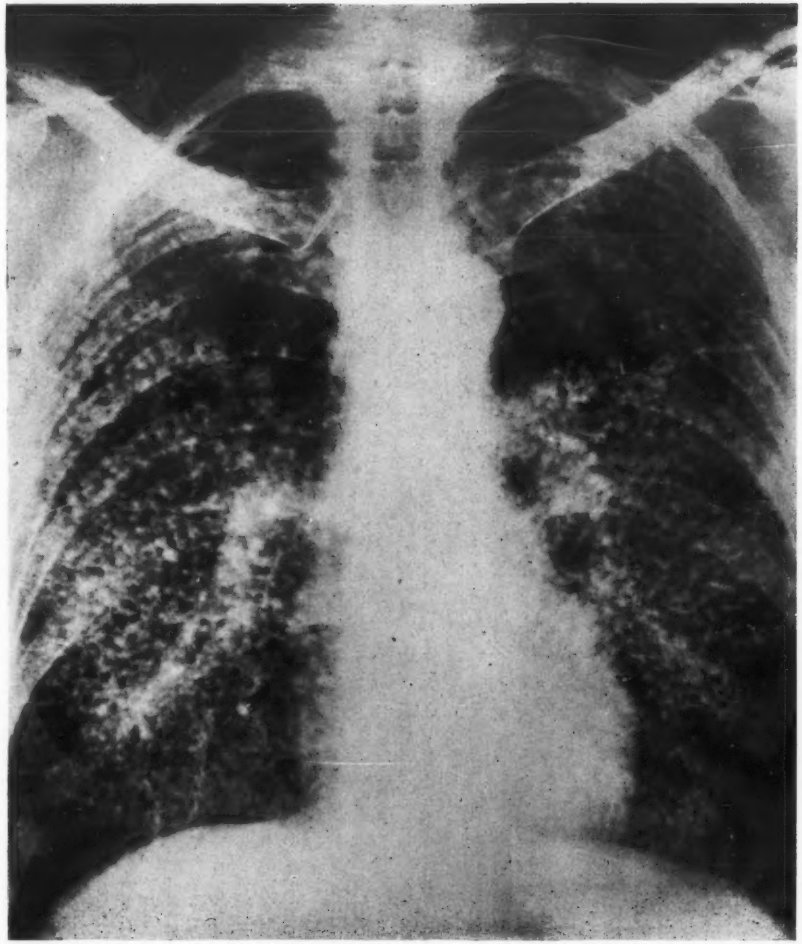

FIG. 8.—Radiograph of a lung showing nodulation.

FIG. 9—Detail from fig. 8. Man aged 59 ; iron-ore miner for twenty-six years (twenty-two years on pneumatic drill); progressive shortness of breath for ten years ; cough, and diminished chest expansion ; dyspnoea on exertion ; pulmonary fibrosis and emphysaema; died of pneumonia.

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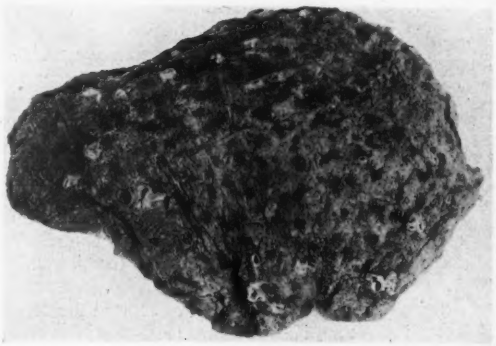


FIG. 10.—Lung of case radiographed in figs. 8 and 9.

FIG. 11.—A typical nodule from the lung shown in fig. 10.

silicosis due to mixed dusts. At necropsy 75 per cent. of these cases have shown conclusive evidence of tuberculous infection.

1. *The massive type* of lesion is most marked in the upper half of both lungs. The areas are completely airless and excessively hard, often with sharply defined margins. The colour is brick red. The less fibrosed area is chiefly basal, and is tough rather than hard and often emphysematous; bullae are frequently present. Fig. 12 shows the radiograph of a lung of this type, and fig. 13 the actual lung.

2. *The diffuse type* of lesion is more uniform in appearance. The whole organ is brick red and obviously fibrosed, with a colour less brilliant and not so hard, and is also emphysematous.

3. *The nodular type* of lesion co-exists with massive lesions, and it is interesting to note that nodules of some size always co-exist with active tuberculosis.

TABLE I

PERCENTAGE INCIDENCE, ACCORDING TO LENGTH OF SERVICE UNDERGROUND, OF RADIOLOGICAL ABNORMALITIES IN 191 MEN

Radiological classification	Number of years underground											
	less than 10		10–20		20–30		30–40		40+		Total	
	No.	per cent.	No.	per cent.	No.	per cent.	No.	per cent.	No.	per cent.	No.	per cent.
Normal	44	89·6	47	70·2	24	53·3	7	35	1	10	123	64·5
Reticulation	3	6·2	16	23·9	19	42·3	9	45	2	20	49	25·4
Nodulation	0		0		0		2	10	0		2	1·1
Massive consolidation ..	0		1	1·5	1	2·2	2	10	7	70	11	5·8
Other conditions, including tuberculosis	2	4·2	3	4·5	1	2·2	0		0		6	3·2
Average age	28		36·5		43·5		52		61			
Average years underground	5·4		14·8		23·3		33·3		44			

FIG. 8.—Radiograph of a lung showing nodulation.

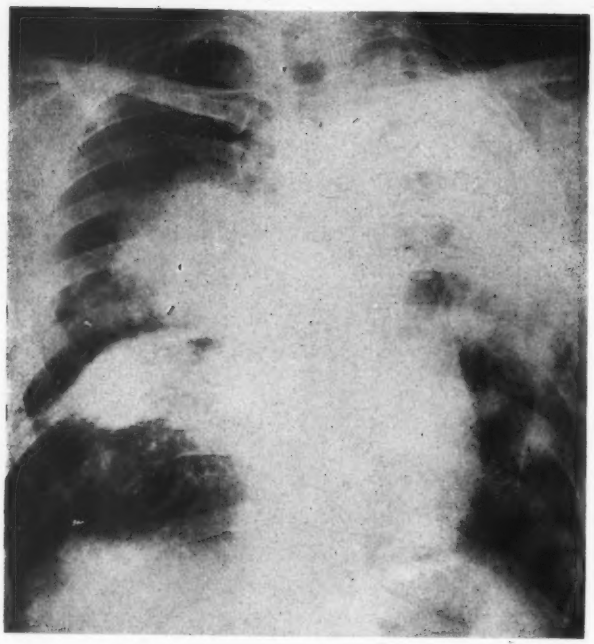


FIG. 12.—Radiograph of a lung with a massive lesion. Man aged 53; iron-ore miner for thirty-two years (twenty-one years on pneumatic drills); progressive shortness of breath for ten years after pneumonia; cough and expectoration with marked dyspnoea; died from advanced silicosis.

FIG. 13.—The lung radiographed in fig. 12.

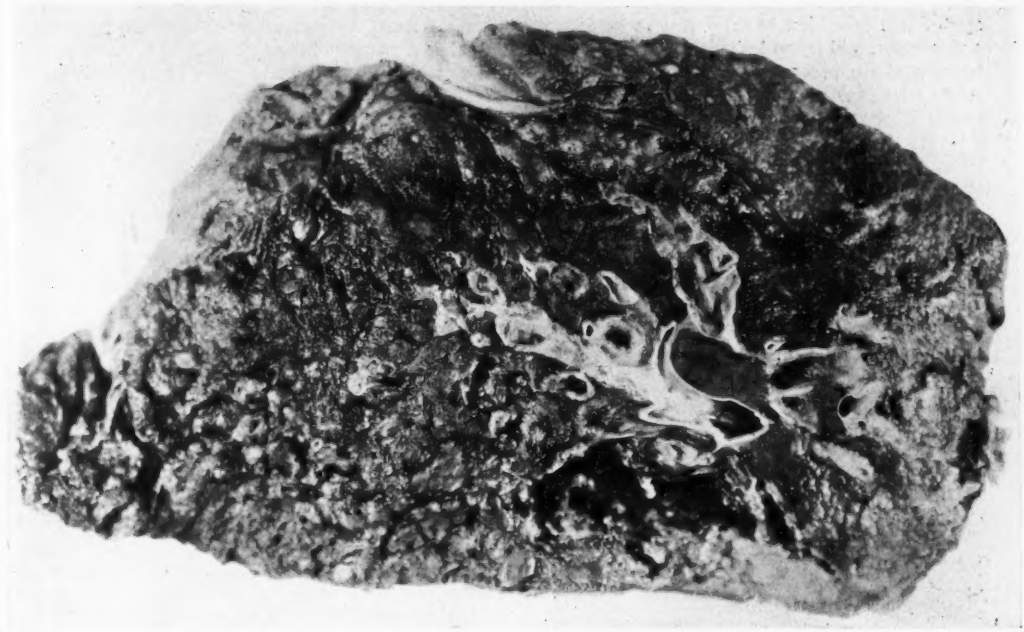
The chemical analysis of the lung illustrated in fig. 13 showed: percentage silica to lung 1·14; percentage silica to ash 7·1; percentage Fe_2O_3 to lung 6·8; percentage Fe_2O_3 to ash 40.

In the aerated lung classical nodules are found and they are present only with active tuberculosis. In the fibro-caseous masses there is nodulation of a closely packed type, and each nodule has a structureless caseous centre with haematite and silica at the periphery. A radiograph of a case of silico-tuberculosis is seen in fig. 14, and the actual lung is seen in fig. 15.

An opportunity was taken to examine two distinct groups of miners, one group from the Egremont district in 1935, and another group from a mine in the Furness district in 1940. The Egremont district group comprised 191 men who had spent their entire working life in these mines, and who were either actually working as miners at that time, or had done so until a short time before the examination. It was impossible to separate the men into drillers and non-drillers, as most men graduated from labourer to full miner in the course of years—sometimes after only two or three years.

Table 1 shows the *x*-ray classification of underground workers according to the length of service in the process.

It will be seen from the table that, under old conditions of mining, progressive changes took place in the miners' lungs. Of 49 men who had served for less than 10 years underground, 89·6 per cent. had normal radiographs, 6·2 per cent. showed the condition of reticulation, 4·2 per cent. showed other changes, actually evidence of healed tuberculous infection. As the number of working years increased, each class showed a progressively smaller percentage of normal lungs. The total number of men over 40 included in the table is very small, but only 1 out of 10 had a normal chest, and 7, or 70 per cent. showed evidence of massive changes. In all, the biggest percentage of abnormal radiological findings was of the reticulation type, the type presenting the most difficult problem.



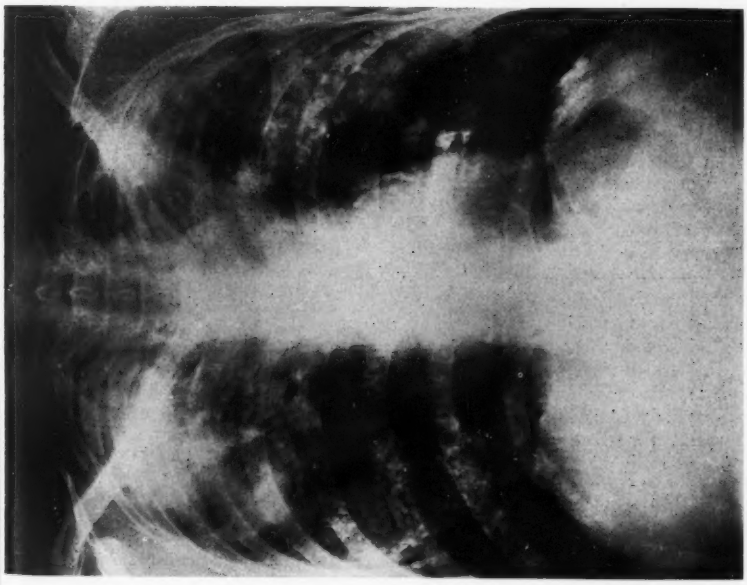


FIG. 14.—Radiograph of a case of silico-tuberculosis. Man aged 44; iron-ore miner for twenty-nine years (thirteen years on pneumatic drills); short history after pleurisy of cough, expectoration, and marked loss of weight; advanced pulmonary tuberculosis with tubercle bacilli +++; died from silico-tuberculosis.

FIG. 15.—The lung radiographed in fig. 14.

The significance of this change and the pathology of this condition have been discussed earlier in this paper, and it has been demonstrated that the changes are due, in most cases, to the simple accumulation of the inspired dust in the lung alveoli and in the lymphatic channels surrounding the blood vessels of the lung. There is no evidence of mature fibrous tissue, which is the diagnostic feature of the classical type of fibrosis. The radiological appearances are due to dense shadows formed by the intense radio-opacity of the particulate haematite.

A detailed and comprehensive study was carried out amongst these men to find out if those with reticulation had been affected physically by the simple accumulation of haematite dust in the lungs. The following is a brief example of the various investigations.

1. *Tolerance to exercise.*—This simple test was carried out in a series of normal men, and in a series of men with reticulation who were of similar age groups, and the difference was not found to be significant.
2. *Total lung volume.*—This was performed in the same men to find out if there was any impairment of the lung reserve amongst men with reticulation; in a series of 310 cases no difference in results was found between men who had not been miners or mine workers, and those miners who showed evidence of radiological reticulation.
3. *History of shortness of breath.*—No significant findings were obtained.

A group of men (84) was similarly examined from a mine in the Furness district. In this mine, the ore is much softer and more easily worked. The chief method of mining is by pneumatic pick, and the amount of explosive used to loosen the ore is consequently much smaller. The age groups were similar to those of the Egremont district group of men, but with a preponderance of older workmen. In the series, 5 men of an average age of 57 years were found to show some radiological changes, rather suggestive of a very early reticular change, but all these men had worked for a number of years in the American copper mines. Of the men who had worked all their life in the Furness district, none showed any evidence of massive shadows, and none showed any evidence of radiographic reticulation.

The difference of the findings for these two districts of Egremont and Furness is significant, as the chemical composition of the ore is very similar, but, as already stated, the physical composition of the two ore-bodies is different, that in the Egremont district being hard and solid, and that in the Furness district softer. In the Egremont district, due to the nature of the ore, dust of very small particulate size is produced by the processes both of drilling and of blasting, whereas the pneumatic picks and smaller explosions in the Furness area probably do not break up the ore mass into such small particles. These facts support the generally accepted theory that the nocuousness of the dust is directly proportionate to the particulate size.

The real proof of the seriousness of a disease cannot be found in statistics of the various types of the condition, but in the number of men who are incapacitated from performing their jobs and from enjoying their lives, and in the number of men who die from the disease. The incidence of deaths from tuberculosis in the haematite industry—as proved by necropsy—is 60 per cent.; and the real death rate may be even higher.

Mining Control

The new régime dates from 1935 until the present day. New conditions in control, both from the mining and medical point of view, have now been in operation for ten years.

Although attempts had been made from time to time to control dust formation by water, the sprays then in use had never been effective. In fact, conditions were often made worse by increasing the relative humidity of the atmosphere. The essential difference in the Wetherill apparatus was that a vapour mist was formed, and the actual water particles were of minute size. This mist is formed by allowing a trickle of water to enter through a T-piece into a pipe through which is blown compressed air. The result is a very heavy cloud or fog which fills the working place. It was soon found that water itself was only partly effective, as much of the fine dust cloud was left floating in the atmosphere, and the wetting effect on the ' dropped dust ' soon evaporated and left conditions bad again as soon as there was any new disturbance to the ' dropped dust.' Thus an agent was required to lower the surface tension of the water globule—and thereby to make them effective in absorbing the small dust particles—and secondly, to make a sticky film on the ' dropped dust ' and so prevent it from being disturbed again. Some oily substance was required, and, after experimental work, castor oil was found to answer the purpose. The oil was contained in a small canister with a supply pipe leading into the compressed air pipe. Fig. 16 shows the apparatus. The proportion of oil to water is about 1 in 100. The holes are first charged with explosive. The shot firer then lights the fuses, and on the way out he turns on the compressed air, the apparatus being previously fixed in position. After the mist projector has been going for 10 to 15 minutes, the working place is found to be atmospherically clear. At first it was the practice to drop a curtain behind the mist projector to confine the process, but it has been found with experience that conditions are much better without a curtain. Soon after the explosion the dust cloud eddies

beyond the confines of the mist, but the cool water mist soon lowers the temperature, and the immediate contraction of atmospheric volumes causes a negative pressure, and the dust can be seen to be sucked in and layed by the mist. The mist projector can be seen in operation in figs. 17 and 18.

Atmospheric Conditions now Prevailing

In the years before 1935 the atmosphere underground was in a constant state of heavy pollution with haematite dust, and, judged by experiments in reproduced conditions, the number of particles was never less than 4 to 5 millions per c.cm; but with the improved ventilation and precautions the atmosphere now appears healthy. In the early years of the experiment, routine dust counting was performed, and it has been the usual practice to test the places where conditions were likely to be at their worst. Approximately 150 dust counts were made during two years in different working places in four of the mines.

An Owen's dust counter was used as routine, and the counts were made with dark-ground illumination and with magnification of 1,100. It is not claimed that the results are accurate, but the results in the series of tests are comparable one with another. The count is a total count, no attempt being made to isolate the silica particles. From estimation of comparable dust in bulk, the amount of silica can be roughly calculated as being less than 10 per cent. on the average. At the same time as the dust sample was taken, wet and dry bulb temperatures were taken and the atmospheric humidity was calculated. Surface temperatures vary from 32° F. to 69° F. and surface humidity from 60 per cent. to 93 per cent. The underground temperature did not vary in proportion to the extremes of surface temperature, hardly ever exceeding 70° F. and maintaining an average

TABLE 2

INCIDENCE OF PULMONARY FIBROSIS AMONGST HAEMATITE MINERS IN WEST CUMBERLAND *

Year	Mine A†				Mine B				Mine C				Mine D			
	Cert. No.	Cases per cent.	Deaths		Cert. No.	Cases per cent.	Deaths		Cert. No.	Cases per cent.	Deaths		Cert. No.	Cases per cent.	Deaths	
			No.	per cent.			No.	per cent.			No.	per cent.			No.	per cent.
1935	0	0	0	0	3	0·7	0	0	1	0·3	1	0·3	1	0·5	0	0
1936	3	0·7	0	0	11	2·8	0	0	0	0	0	0	1	0·5	0	0
1937	4	1·5	3	1·1	2	0·5	3	0·7	4	1·3	1	0·3	0	0	0	0
1938	1	0·4	1	0·4	0	0	1	0·25	1	0·35	0	0	0	0	0	0
1939	1	0·4	1	0·4	1	0·25	0	0	4	1·5	0	0	1	0·6	1	0·6
1940	0		3	0	8	1·7	2	0·4	0	0	1	0·3	0	0	2	0·9
1941	0		1		3	0·6	3	0·6	1	0·4	1	0·4	2	0·9	0	0
1942					0	0	0	0	2	0·8	0	0	0	0	0	0
1943					0	0	1	0·2	3	1·1	1	0·3	1	0·6	0	0
1944					6	1	3	0·5	4	1·5	1	0·3	0	0	1	0·6
Total No.	9		9		34		13		20		6		6		4	
Av. Incidence		0·77		0·77		0·68		0·23		0·61		0·2		0·36		0·24

* Results have been calculated from the following data: (*a*) The number of cases certified as suffering from silicosis (all types) by the Silicosis Board in each year from 1935 to 1944. The first column shows the actual number of cases occurring in that year, and the second shows the average annual rate in relation to the number of workmen. (*b*) The number of cases certified by the Silicosis Board as having died from silicosis in the same year periods, with the average death rate in the second column. A comparable table has been made for each mine. The total number of cases and total number of deaths are also shown for each mine.

† Mine A was a very old mine and working conditions were very difficult. Ventilation was inefficient and difficult to maintain and temperatures were often high, and associated with high humidity. The mine was finally closed in 1939. The silicosis incidence for the five years was 0·77 per cent., and all the cases were of advanced silico-tuberculosis. Two years after the closing of the mine, all the cases had died of open tuberculosis. The other mines are more comparable in type and in numbers of men employed.

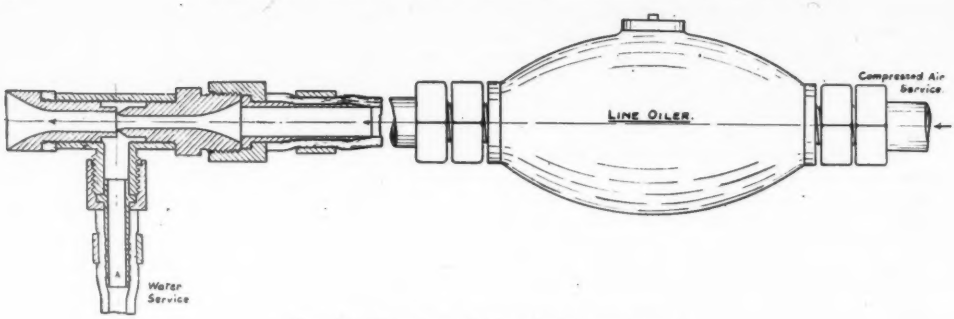


FIG. 16.—Diagram of dust-allaying projector.

FIG. 17.—Projector in action.

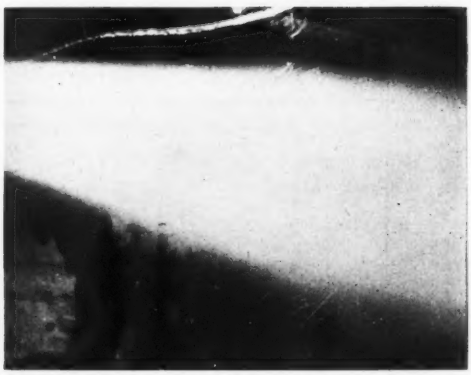


FIG. 18.—Projector in action.

of about 60° F. Even when the temperature was high in midsummer, it was found that generally the temperature underground was less than that on the surface. This is certainly due to the cooling effect of the water mist. The relative humidity underground was always 90 per cent., because of the constant presence of mist from the sprays. Table 3 shows the average dust concentration associated with the various types of work, and in the various places.

The mean dustiness throughout the working roads is in the region of 2,500 per c.cm., which means that, on an average, the number of particles of silica is 250 per c.cm. Size estimation by graticule shows that 87 per cent. of the particles are less than two microns in size, and this remaining dust is, in the author's opinion, difficult to reduce by any practical means according to our present knowledge. One of the mines was examined after 13 days lying idle, and even then it was found that dust counts in various localities varied from 140 to 210 particles per c.cm. In spite of the fact that there is still an appreciable amount of dust in the mines, it is certain that the actual dust concentration is now only a small fraction of what it was under the old conditions of working. In

TABLE 3
AVERAGE DUST COUNT IN UNDERGROUND CONDITIONS

Location	Particles per c.cm.		
	Type of work	Range of counts	Mean count
Bottom downcast shaft		0–1,120	420
Bottom upcast shaft		660–6,100	3,030
In solid place ..	drilling	1,782–3,980	2,540
In working end..	filling	500–5,910	2,270
10 minutes after blast with spray		2,200–3,920	3,060

addition to the fact that the dust is so much less in amount it is also present in a different form of concentration. Numerous dust particles are bunched in an ' oil water ' globule and this conglomeration of particles represents a mass of over 20 microns in size, which is much too large to be inhaled into the lung alveoli. It was thought that, owing to the silica particles being so much lighter than those of haematite, the ratio of silica to haematite would be much higher in the air-borne dust, but samples taken from various baffles of the labyrinth show the ratio to be strictly comparable to the ore being mined in the immediate vicinity.

Medical Control

As previously stated, ideal medical control necessitates the following conditions:

1. Pre-employment general examination to ensure that a man reaches an excellent general physical standard to fit him for the strenuous physical work that he will be required to perform.
2. Special examination of the lungs to ensure that this system is as perfect as possible. This necessitates a radiological examination.
3. Periodic complete medical examination at selected intervals to ensure that the workman's general condition remains satisfactory, and that his lungs are remaining free from evidence of dust inhalation.

Pre-employment examination

In pre-war days these examinations were arranged through the mines management, and after the man was found suitable he was referred to the medical clinic. Now arrangements are made through the Ministry of Labour. It is a simple matter to do a routine examination and to say that a man has reached a certain physical standard, but it was soon found that ' a fit man was not necessarily a man fit for the hazards of mining.' During the large-scale examination of men who had worked in the mines, it was soon discovered that men were not all the same physically, and, moreover, it was found that the different types could be classified. In the main, there are two large physical groups (Kretchmer, 1934).

1. *Pyknicosomatic.*—Generally the man is of small stature and thick set, with short extremities, rounded, well-nourished appearance, and fresh complexion. The skeleton is small, and the fat on face, neck, and trunk is generous. The abdomen is large. The shoulders are narrow, and the chest tends to be barrel-shaped. These appearances become much more apparent in middle age, but the extreme type usually shows the characteristics in the middle twenties. This extreme type has a low lung reserve; in breathing his ribs rise forward in association with abdominal breathing. This group represents only 5 per cent. of the total of this class, yet in table 1, of the three cases of men who had worked underground less than 10 years and who showed radiographic reticulation, all belonged to this physical category.

2. *Leptosomatic.*—This is the other large physical group, and the extreme of this group is the asthenic type. They have an angular profile, the shoulders are narrow and sloping, the back is bent forward, and the thorax is round and long. This class represents about 10 per cent. of the male population of this district.

3. *Intermediate.*—Between these two groups is the large group of mixed types representing 85 per cent. of the male population of this district.

Of 49 consecutive cases with radiological changes who were suffering from shortness of breath of such a degree as to make them unfit for work, table 4 shows the different radiological categories classified according to the physical types of men.

TABLE 4

CASES OF CERTIFIED SILICOSIS CLASSIFIED ACCORDING TO PHYSICAL TYPES OF MINERS

Type	Reticulation	Massive consolidation	Infective	Total
Extreme ' Pyknic '	8	6	1	15
Middle mixed ..	3	7	2	12
Asthenic ..	0	7	15	22

These findings suggest that the extreme pathological changes due to the inhalation of haematite iron ore dust occur predominately in the two extreme physical types of men, and, in consequence, these extreme types are not accepted for underground work.

Tuberculosis.—In choosing new workmen who have not been in mining before, and this includes a large number of youths between the ages of 14 and 18, other conditions are often found which necessitate rejection, and the commonest single condition is tuberculosis. Of 883 recruits between 14 and 40 years of age who have been examined radiologically during the last nine years, 4 (0·45 per cent.) had active pulmonary tuberculosis, and 5 (0·56 per cent.) had inactive pulmonary tuberculosis. (The incidence amongst men with previous mining experience was much higher—see table 1.) Of the total, 883, 133 were rejected for other conditions, including history of past illness—especially pulmonary—and failure to reach the requisite physical standard. Thus, 15 per cent. of entrants were rejected. Amongst men with mining experience a

much higher number was rejected, only 60 per cent. being accepted.

Very careful notes are taken at the pre-employment examination, and these are recorded on a medical card which is retained in a card index, the *x*-ray film is filed in a similar manner. The reverse of the card provides space for the records of follow-up examinations ; thus as the years go on a serial record is obtained of new illnesses, the type of work that the man has been performing, his height, weight, *x*-ray findings, pulmonary capacity, etc. It was decided that a yearly examination should be carried out on each man, and this was done until the second year of the war, when travelling became too difficult. But during the last few months the former routine has been resumed, and arrears of examinations are being made up.

Disposal of Rejected Men.—Of the total number of men rejected, 98 per cent. are medically fit, and the only reason for rejection is that they are not considered fit for an industry that has a silicosis risk. A note is made of those who have active tuberculosis, or who have had tuberculosis which has become healed, and a full note, with the *x*-ray film, is sent to the family doctor. These cases are either notified and treated, or kept under observation by the tuberculosis authority.

After 10 years 56 per cent. of the underground population in these mines are picked men who have been chosen carefully and are known to be in good health and with no radiological evidence of haematite accumulation in their lungs. They are also known not to be suffering from tuberculosis. Of the underground population under 40 years of age, 69 per cent. are picked men. The percentage of 'new miners' in each age group of underground workers is as follows: under 20, 100 per cent.; 20 to 29, 89 per cent.; 30 to 39, 59 per cent.; 40 to 49, 39 per cent.; 50+, 20 per cent. It is estimated that in another 10 years, with a normal intake of new men, 100 per cent. of the age group 20–30 will be chosen men, and almost 70 per cent. of the entire underground population will be 'new miners.' Of workmen under 40 years of age employed in the haematite mining industry, the death rate from pulmonary tuberculosis is now nil.

Results of Mining and Medical Control

As it is now 10 years since the institution of 'new miners' and new methods of dust control in the Egremont area, it is possible to draw some conclusions as to the effectiveness of the control methods. It is proposed to consider only the men who began work underground during the years 1935, 1936, and 1937, as this ensures that the men have had an average of over 8 years as underground workers. Some of the 411 men who were accepted during these years have been on surface work, so they were not taken into account for this study. There has also been a large wastage from men going to other work or joining the Forces. The number of men is thus only 66, but they have all had experience of actual machine work.

Table 5 shows in the first column the 49 miners examined who worked in the old conditions with less than 10 years' experience underground. This is the same as in table 1. In the second column is shown the result of examination of the total number of 'new miners' with from 8 to 10 years' experience underground in the new conditions of mining and medical supervision.

TABLE 5

COMPARISON OF INCIDENCE OF RADIOLOGICAL CHANGES BETWEEN UNSELECTED MINERS IN OLD WORKING CONDITIONS AND SELECTED MINERS IN NEW WORKING CONDITIONS.

	Men under old conditions (less than 10 years underground)		New miners (8 to 10 years underground)
		%	
Normal radiograph	44	89·6	66 100%
Reticulation ..	3	6·2	0
Nodulation ..	0	0	0
Consolidation ..	0	0	0
Other lesions ..	2	4·2	0
Total	49	100	66
Average age ..	28		27
Average years underground ..	5·4		8·3
Average years on machines ..	0		3

The new series shows that there has been no radiological change in the lungs of any of these men, the condition being exactly as it was 8 or 9 years ago. Thus at the present time it appears that 100 per cent. success has been achieved. It was hoped to be able to do a complete medical survey of the mines, but this has been impossible to achieve for many

reasons. It has been possible, however, to examine 39 men who had been employed underground for from 20 to 30 years. These were all men who had worked underground until the day of examination and who were either being examined for some other reason, or who were being transferred from one mine to another. These men had not been examined before their original employment, and were, therefore, not physically picked men, but they had worked for almost half of their time in the new conditions of mining. Table 6 shows in the first columns the miners working under the old régime, and the second group are those who have worked for almost half their underground working life in the new conditions. Although the number in each group is small, the groups are comparable in numbers, average age, and average number of years worked underground, and each is an unselected sample.

Since the inclusion of this industry in the Silicosis Compensation Acts, the men have become ' silicosis minded,' and for some years the occupation of iron ore miners has not been a popular one. The men began by mistrusting the compulsory pre-employment medical examination, as they thought that the sole idea of the owners was to get rid of their obligations. Now that the men are realizing that the system is for their own good they are becoming reassured. It has now been possible to inform these new miners that 10 years' work underground has had no deleterious effect on their lungs, and it has been possible to convince them that they have actually improved physically.

Discussion on Pneumoconiosis due to Mixed Haematite Dust

From our present knowledge of the condition, it is agreed that industrial pulmonary fibrosis is due to particulate silicon dioxide (SiO_2), and it must be inhaled in particles smaller than 5 microns in order to reach the lungs and cause an injurious reaction. The purer the silica the more closely does the reaction in the lung approach the classical type as exemplified in the South African Gold Field. In the case of haematite mining the reaction is in most cases very mild and very slow, and in ' radiological reticulation ' the dust is practically lying inert, with none—or a very minimal—reaction in the host lung, the radio-opacity of the haematite iron ore giving the dense radiological picture. Experiments by Kettle (1932) proved that iron alone causes no reaction; in fact, by coating silica with iron he could prevent any reaction in the lung from occurring, and Carleton (1927), using haematite, was quite unable to demonstrate any fibrous reaction in the lungs of rabbits. The conclusion to be drawn from these findings is that the admixture of an inert dust retards or inhibits the reaction of silica and this has been proved by the brilliant work of Briscoe and others (1937). Attempts have been made in this clinic to confirm this work, and it was found that

TABLE 6

COMPARISON OF INCIDENCE OF RADIOLOGICAL CHANGES IN MINERS WHO HAVE WORKED ONLY UNDER OLD WORKING CONDITIONS AND SELECTED MINERS IN NEW WORKING CONDITIONS.

Radiograph	Men under old conditions				Men 10 years in new conditions			
	No.	per cent.	Average age	Average years underground	No.	per cent.	Average age	Average years underground
Normal	24	53·3	43·2	22	33	84·6	41·5	23
Reticulation	19	42·3	43·8	24	4	10·3	45	25
Nodulation	0	0			1	2·55	48	29
Massive consolidation ..	1	2·2	42	25	1	2·55	39	25
Other conditions, including tuberculosis	1	2·2	40	21	0	0		
Total	45	100			39	100		
Average years underground..				23·3				23·4

TABLE 7

SILICA AND IRON CONTENT OF LUNGS OF IRON ORE MINERS ACCORDING TO PATHOLOGICAL CLASSIFICATION (NUMBER OF CASES IN BRACKETS)

Pathological classification	Age	Years underground	Percentage silica to		Total silica	Percentage Fe to		Total Fe	Percentage Ash	Ratio Si/Fe
			Lung	Ash		Lung	Ash			
Reticulation (14)	58	37	1·42	8·3	3·58	9·8	49	23·5	19·7	1/7·5
Nodulation (6)	57	29	0·96	6·0	2·21	7·2	45	21·3	14·6	
Massive fibrosis (12) ..	57	40	1·7	8·1	6·3	10·3	47	47·5	21·4	1/6
Massive fibrosis and open tuberculosis (30) ..	56	33	1·4	8·9	5·7	6·6	42	27·3	15·7	1/4·5
Tuberculosis alone (6) ..	32	16	0·16	2·8	0·96	0·52	8·6	3·9	5·6	1/3·9

with haematite dust containing 8 per cent. SiO_2 the solubility of the silica was markedly depressed. In spite of the fact that haematite is known to retard the action of silica in the human lung, it has been abundantly proved that pulmonary fibrosis has occurred in the past; and, in fact, we are still seeing cases at the present time, although these cases certainly developed the condition while working under the conditions of mining that were prevalent before 1935. Is it possible to say what is the causal factor, and is only one cause responsible?

The Rôle of Silica

An exceilent opportunity has been presented by a large-scale review of necropsy material. During the last 10 years 78 necropsies have been performed by Dr. Faulds, pathologist to the Cumberland Infirmary, on haematite miners who were known or suspected to have died of silicosis. A chemical analysis has been done on these lungs by Dr. Faulds and he has kindly allowed me to use his results. The silica and iron content has been estimated, and the results are shown in Table 7 under the varying radiological classifications confirmed at post-mortem examinations.

The age and the average number of years spent underground is strictly comparable for each group.

Percentage Silica to Lung.—These figures show no significant difference when comparing the various pathological groups, and it is worthy of note that nodulation, which is a stage advanced from reticulation, shows a lower percentage of silica; the percentage silica to ash compares closely in ratio to the previous column.

Total Silica.—Here we have a significant change in the amount of silica present in lungs showing massive fibrosis, and massive fibrosis with tuberculosis, when compared to those showing reticulation and nodulation. Is this difference due to the original presence of more silica in the lungs or is there some other factor operating?

Tuberculosis.—It has been shown both anatomically and chemically that these lungs contain large quantities of haematite, and as much silica as is usually present in ordinary cases of silicosis. Yet *x*-ray reticulation shows no fibrosis, although the amount of silica is quite adequate to produce actual silicosis. Tuberculosis is one obvious factor, and in cases of massive fibrosis without obvious tuberculosis, some evidence of very old and long-standing tuberculosis can often be found, and the large total silica and haematite content of these lungs is probably due to their being anchored in the lungs by the inflammatory fibrotic processes (probably almost always tuberculosis).

The coalescent or massive fibrosis is usually described as a merging together of discreet small nodules to form a new large mass, but in haematite fibrosis the large mass is certainly not formed in this way but always by a new inflammatory condition being superimposed, and the resulting masses are a direct outcome of the new process which in the large majority of cases is tuberculous.

A warning should be given about over-enthusiasm in the use of aluminium either in a preventive or curative capacity. Aluminium is in itself alleged to be innocuous; haematite also is innocuous. Aluminium depresses the solubility of silica, as does haematite; but in spite of these facts, it must be remembered that test-tube results cannot be applied to the human lung, and even the findings in animal experiments cannot be applied to human beings.

Too much reliance may be placed on these highly artificial methods, when it is only after a time-lag of 20 years that the effectiveness or otherwise of such a method can be truly assessed.

Conclusions

This paper has formulated the methods, both medical and engineering, for the control of pneumoconiosis in the haematite mining industry in West Cumberland, but this is only part of a general service to improve the lot of the worker in these mines; to make him a better and happier workman, and to permit him to enjoy his work and leisure in comfort and good health. Such a service has now been functioning for more than 10 years, and the results are indeed heartening, but it is only as a result of constant vigilance from the mining and medical point of view that the plan can operate efficiently. The human element and its full understanding is by no means the least of the problems.

The mist projector is almost useless if it is not used efficiently, and it is found that three main reasons operate constantly in attempting to cancel out the benefits.

1. The enthusiasm of the hard-working miner tends to make him re-enter the working place much too soon, and before the spray has had enough time to do its work.
2. The laziness of some workmen make them just ' not bother ' and so they jeopardize not only their own future good health but that of their fellows.
3. Familiarity breeds contempt and with it carelessness.

The answer to these questions is an efficient and understanding management, and in this matter it has been the good fortune of the controllers of these experiments to have had men who have known the old conditions, and the miseries and discomforts that have been a relic of these conditions. This knowledge has been a driving force in improving conditions and maintaining them, but it is because of the long time-lag before the good results of dust suppression are seen that the greatest care must be taken in maintaining the enthusiasm of the workmen.

A final word must be said about the mutual respect and trust between the medical officer and the management on the one hand, and the workmen on the other. From the medical point of view the relationship of doctor and patient must be maintained inviolate. If the medical officer finds, during a routine examination, that there is some deviation from the normal health, whether it be from an occupational or other cause, his duty must primarily be to the patient, who has an absolute right to an explanation of the reason for the medical officer's opinion. It may be that, in the future, cases will be found who show early evidence of dust inhalation, and it is the object of this organization to take such a man away from risk and provide for him some other means of earning a living, and there must be no prejudice against the workmen. It is to be hoped that such a necessity will not arise, but ways and means should be found for the just disposal of such a case.

Summary

1. The haematite deposits are in two locations, north and south. The north mines produce pulmonary fibrosis, the south do not.

2. The disease has probably been prevalent for at least 40 years, i.e. before the advent of pneumatic drills.

3. Uncomplicated pneumoconiosis or radiological reticulation is not, of itself, an incapacitating condition. The single incapacitating and death-causing factor is infection, usually tuberculosis.

4. The condition of dustiness in the West Cumberland mines before 1935 was intense, many millions of particles per c.cm. A new regime was introduced in 1935. Dust allaying by the mist projector has diminished the dust content of the air to an average of 2,500 particles per c.cm., i.e. approximately 250 particles of silica per c.cm. A complete medical service selects only fit men for work. Workmen are radiographed before admission and periodically thereafter. The results of engineering and medical control has resulted, after a 10-year period of trial, in 100 per cent. success.

5. Although it is too soon to predict, it is suggested that silicosis will probably cease to be a problem if the incidence of tuberculosis is strictly controlled and eventually eradicated.

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BYSSINOSIS IN THE COTTON TRADE*

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The word byssinosis is derived from the Greek word βυσσος, meaning fine linen. Originally the word was used in a wider, more general sense, whereas to-day it indicates a specific industrial entity. Byssinosis is a respiratory disease affecting workers inhaling dust in cotton mills. The condition has been known to exist for many years, and was first recorded by Greenhow in a report to the Privy Council of London in 1861. The cotton trade has been the Cinderella of occupational hazards and it is only recently that research into the causes of byssinosis has been undertaken. In 1930 the Industrial Health Research Board published a study of sickness among operatives in Lancashire cotton mills, and in 1932 the Home Office issued the *Report of the Departmental Committee on Dust in Card Rooms in the Cotton Industry*. This report collected the existing information about conditions in the mills, types of machinery in use, and the nature of the cotton dust, and included an account of the clinical examination and radiological findings in a group of workers suffering from the disease. The post-mortem findings in a few cases where death had occurred were also described.

In 1936 Prausnitz published an account of investigations on respiratory dust disease in operatives in the cotton industry. The mass of information from these two reports gives the most recent and authoritative knowledge on byssinosis, and forms the structure on which further investigations can be based. Foreign literature on the subject is scanty and does not contribute any additional knowledge. Zipperlen (1935) reported on an investigation of patients suffering from asthma in Württemburg, where there is a textile industry. His report contained the following statement: 'A few words should be said concerning industry. In spite of all protective appliances cotton dust cannot be excluded, and we have actually observed a large number of severe asthma patients in whom strong allergic reactions could be obtained with suitably prepared dust from the factories.'

The Process

Cotton is obtained chiefly from Egypt, America, and India. Although cotton dusts show variations, there is no evidence that such variations materially influence the injurious effect of long-continued inhalation. The cotton arrives in this country in bales, highly compressed and containing particles of leaf and seed coat, cotton hairs, fragments of mould, and fine sand. The raw cotton has to be cleaned, and it passes through several processes in the cotton chamber and blowing room before being ready for the card room. In the cotton chamber the bales are uncovered, and the tightly compressed cotton is pulled off in layers and hand-fed by the cotton feeder into a machine known as a hopper bale opener. It then passes into the blowing room, where it is dealt with successively by hopper openers, hopper feeders, porcupine openers with high-speed Shirley cages attached, and finally by Crighton openers and finisher scutchers. The purpose of all these machines is similar, namely, to open out the compressed cotton, to spread it well, and, by a beating action aided by powerful currents of air, to free it from a high percentage of its impurities and at the same time ensure adequate mixing of the different qualities of cotton. With the exception of the cotton feeder tending the hopper bale opener, all the machines are enclosed in dust-proof covers. The machines, however, have to be hand-cleaned, and this is a particularly dusty job; the operatives engaged on this work are suitably clothed and wear respirators. The cotton, emerging from the blowing room, passes to the carding engines: and it is here that trouble from byssinosis begins, for, though the Industrial Health Research Board report showed that blowing-room operatives had high sickness rates from respiratory causes, it was thought that

* Based on a paper read to the Association of Industrial Medical Officers in Manchester on May 16, 1946.

this might have been due to transfers from the card-room taking up work there. Women working in the card-room, the engine-head tenters, slubber tenters, and intermediate tenters are only rarely affected by byssinosis. It is, in fact, the strippers and grinders, the operatives in charge of the carding engines, who are the principal sufferers.

Usually each stripper and grinder is in charge of 16 carding engines (fig. 1): each engine is cleaned four times daily by a vacuum process (fig. 2), and twice weekly it is brush stripped (figs. 3, 4, and 4A). The brush stripping is necessary because the vacuum process fails to clean sufficiently deeply, and the evidence is very strong that the dust liberated by the carding process in the immediate vicinity of the carding engine contains the injurious element or elements causing byssinosis. The farther away from the carding engine, the safer the atmosphere.

Symptomatology

For convenience the symptoms of byssinosis may be divided into two stages—early and late.

The early stage.—Although not so common to-day as it was some years ago, the condition called mill fever, Monday morning fever, or factory fever is known to many card-room operatives. On entering the card room on Monday morning these workers experience a dry, irritative feeling in their throat and chest. This is followed by a short, slight, dry cough. There may be an attack of sneezing; and, in a few cases, principally among the women, a slight urticarial type of rash appears on the forearms. Some operatives complain of sore eyes; a mild conjunctivitis is sometimes present. After a few hours—or at most a day or so—the symptoms disappear, and for the remainder of the week no discomfort is experienced. There is little or no constitutional disturbance. The appetite remains good, and the condition does not result in a loss of working hours. A few operatives exhibit a mild pyrexia, not sufficient to incapacitate them. Many never experience mill fever. Others experience it for a few weeks or months and then apparently become immunized. Some years ago the condition was regarded by such workers as a necessary baptism to their trade. In some operatives—who might be described as the card-room-susceptible type—the condition subsides only to recur after months or years, or never subsides entirely, but continues as mill fever. Except in strippers and grinders, mill fever at this stage rarely progresses any further or causes any serious respiratory damage. The symptoms and recurring cyclic nature of mill fever, however, do seem to suggest an allergic sensitivity to some constituent in the cotton dust.

The late stage.—The stripper and grinder is the operative who usually succumbs to the late stage of mill fever. The symptoms of fever gradually reappear ten or twenty years after the earlier attacks—that is, when the workers are 35 or 40. The cough becomes dryer, harder, and of a metallic character; and symptoms tend to spread over all the working days of the week. At first there is little sputum; after a severe attack of coughing a small quantity of clear, sticky, glairy mucus is brought up with great difficulty. The patient at this stage complains of easy fatigue, and his capacity for effort is considerably reduced. After a week or so off work most of the symptoms abate, the cough moderates, the physical capacity improves, and the operative is again fit for his job. With intervals of rest from work, the stripper and grinder may continue for several more years. Insidiously, however, the condition progresses. In the later cases expectoration becomes freer and possibly muco-purulent; dyspnoea increases, and the capacity for effort decreases. Operatives will tell you that several times on their way to and from work they have to stop to get their breath. They complain of tightness in their chest—'I feel as if I had a rope tied round my chest.' Inspiration is difficult. Attacks of bronchitis become increasingly frequent, and more and more time is lost. Ultimately the continued cough, dyspnoea, easily induced fatigue, and loss of sleep due to asthma-like nocturnal attacks, render the sufferer unfit for this work, and, unfortunately, in many cases unfit for alternative work: there is the tragic picture of a man in middle life condemned to chronic invalidism. The constant complaint of strippers and grinders at this late stage is that they have to sit up in bed at night to get their breath.

Physical Signs

Clinical examination of operatives suffering from mill fever in the early stage does not reveal objective signs except those already mentioned, though the mucous membrane of the nasopharynx may be somewhat thickened and hyperaemic. Examination in the late stage reveals the classical signs of chronic bronchitis and emphysema. The patients at this stage look ill, their skin has an unhealthy, sallow colour, the cheeks are sunken, and there is general loss of weight. Respiration is laboured, with the accessory muscles called more and more into use. The diaphragm moves badly. The shoulders are raised, and a stooping, kyphotic

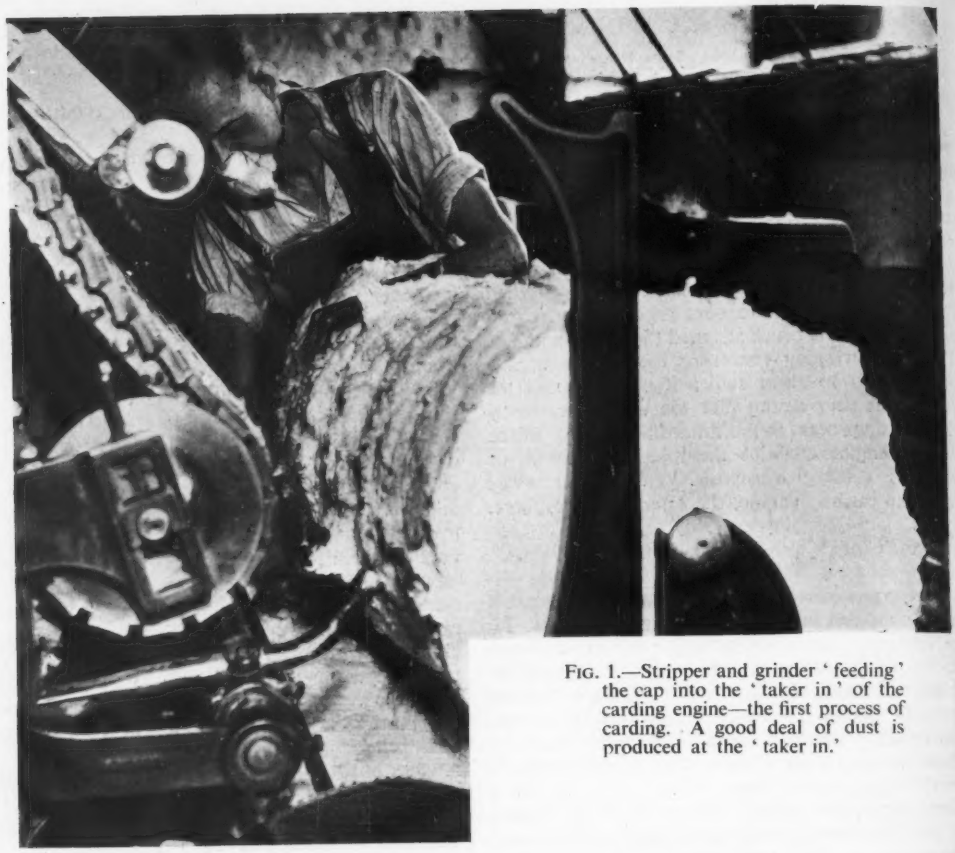

FIG. 1.—Stripper and grinder 'feeding' the cap into the 'taker in' of the carding engine—the first process of carding. A good deal of dust is produced at the 'taker in.'

FIG. 2.—Cleaning by vacuum process. (It was found unsatisfactory to take this photograph with the machinery actually in motion.)

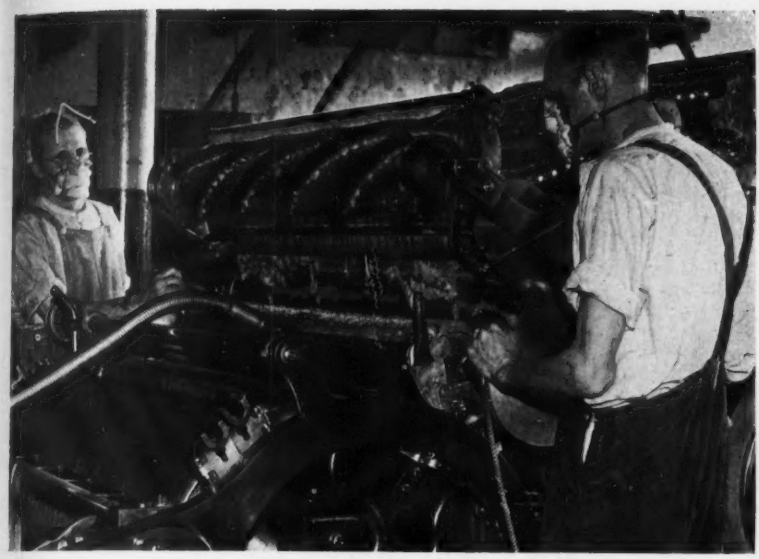

FIG. 3.—Brush-stripping and grinding. Similar operation using (*a*) brush, (*b*) emery roller. Requires two operatives.

FIG. 4.—Stripper and grinder cleaning out 'fly,' 'trash' and fine dust from underneath the carding engine. A very dusty job. (See Fig. 4A.)

FIG. 4A.—Cleaning out 'fly,' 'trash' and fine dust from underneath the carding engine by recently installed vacuum process. Note the dust extraction hood which can just be seen over the carding engine.

curvature is common. The patients sit in a characteristic attitude, the body bent slightly forward, the legs spaced widely, and the hands placed on the knees. The thorax becomes typically barrel-shaped, with the usual prominent sternum. In fact the patient exhibits the physical signs of extreme emphysema. The vital capacity of the thorax is greatly impaired, and the chest expansion of these late cases is often found to be only one or one and a half inches.

Between the early mill-fever patient and the late stage just described, there are many intermediate types. The progressive tendency for the vital capacity to decrease often precedes the stage of advanced pulmonary damage. Alternative work should therefore always be advised for any operatives exhibiting this feature. Another early sign is a slow but progressive loss of weight.

Radiographic Appearances

Among 100 patients* who had radiographs taken of their chests, no specific appearances diagnostic of byssinosis were detected. In the late stage changes

* These cases were radiographed by Dr. George Fletcher, Chief Tuberculosis Officer, Lancs. C. C. My own series were radiographed by Dr. A. Richardson, Radiologist to the Oldham Royal Infirmary: his reports agree with Dr. Fletcher's.

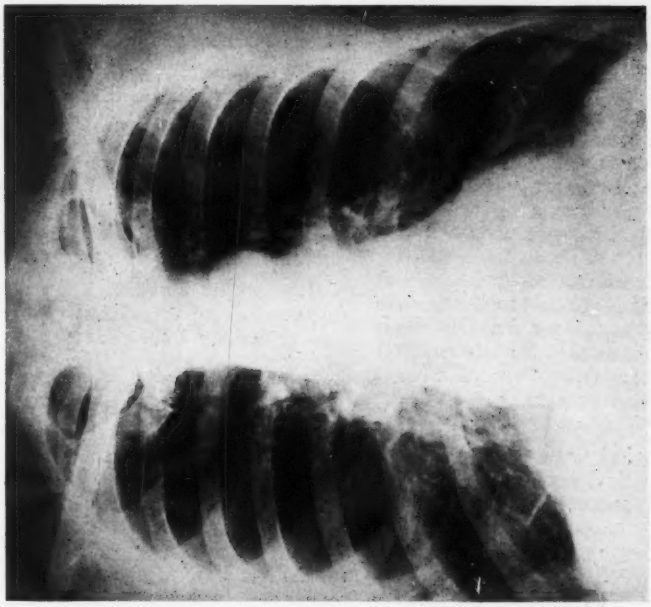

FIG. 6.—Radiograph of a man 45 years of age with typical clinical signs of byssinosis. He has been found alternative work outside the card-room.

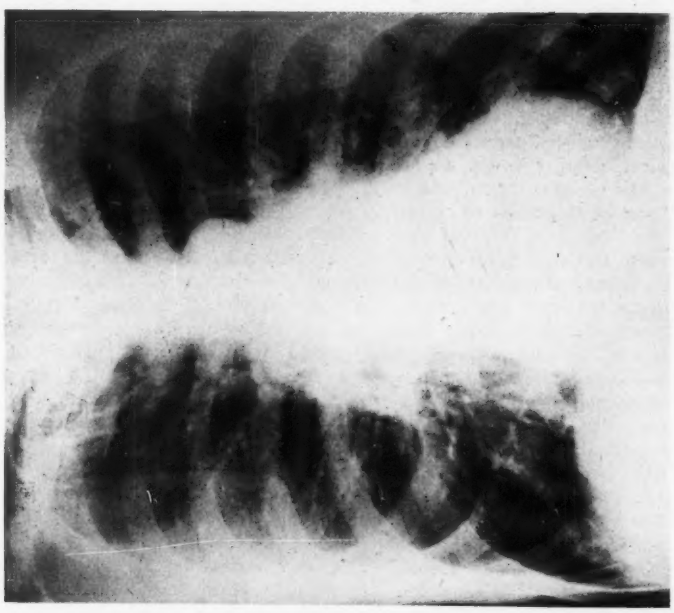

FIG. 5.—Radiograph of an advanced case of byssinosis. The patient, now aged 60, has not been able to work for many years.

were consistent with those of chronic bronchitis and emphysema. The films, however, tended to show bronchial shadows of a greater intensity than those generally found in patients suffering from bronchitis and emphysema (figs. 5 and 6). Cotton dust is not ' aggressive ' in the same way as the causative dusts of asbestosis or silicosis, and *x*-ray films are not, therefore, a pointer to diagnosis, as they are in these latter diseases. Diagnosis of emphysema due to cotton dust rests, in fact, only on a history of exposure for many years, on the patient's symptoms, and on clinical examination. A successful appeal for compensation for byssinosis requires that the patient shall have been exposed to the dust for a minimum period of 20 years. Claims for compensation are made under The Byssinosis (Benefit) Scheme, 1941 —assessment being in the hands of a medical board appointed by the Secretary of State.

Pathological Changes

Post-mortem examinations have been carried out in ten cases. The examination has revealed no specific feature for byssinosis, the changes in the respiratory system being those of bronchitis and emphysema. Dilatation of the right heart was frequent in the series of cases examined post mortem by Dunn and Sheehan (1932).

Causative Agent

A complete investigation of the causative agent of byssinosis has been carried out by Prausnitz, who used Shirley cage dust as providing the best cross-section. The dust consisted of a greyish-brown fleecy material, which, if shaken, produced masses of fine grey dust which remained floating in the air for a considerable time. Microscopical examination showed the dust to consist of fragments of cotton fibre and green and brown scales of the leaf and husks. There was no sand, and, in fact, no demonstrable mineral matter. When the dust was examined by the ultra-microscope, extremely fine particles became visible; there appeared to be no lower limit to the size of these particles. It was reasonable to assume that these ultra-fine particles could readily find their way into the deeper portions of the respiratory system, even to the extent of passing through the alveolar wall into the inter-alveolar tissues.

Animal experiments have demonstrated the power of cotton dust to penetrate into the deepest parts of the lungs and to produce a chronic inflammatory reaction. Numerous experiments have also been carried out on individual fractions of cotton dust. From these experiments Prausnitz (1936) suggested that the pathogenesis of the illness was as follows:

1. Irritating soluble protein of the cotton dust penetrated into the alveolar tissue and gradually produced thickening of the alveolar walls.

2. Simultaneously, or perhaps even before, supersensitiveness was acquired.

3. Superficial irritation of the bronchial mucous membranes by the dust led to chronic bronchitis and cough—in some cases accompanied by intensive expectoration—and ultimately to emphysema.

Probably a percentage of strippers and grinders are predisposed to become sensitive to cotton dust, while others are immune. The allergic or sensitized subjects become the victims of mill fever. They tend to develop a chronic cough, which, helped by irritation of the bronchial mucosa, leads to mild bronchitis. The deep penetration of the respiratory system by the ultra-microscopic portions of the dust—with their protein content—causes a thickening of the alveolar walls and peri-bronchial inflammation; and this state eventually leads to the development of emphysema. It is difficult to escape the convictions that an allergic condition pre-exists, and that it probably prepares the way for the late stage of peri-alveolar thickening. The author has not yet seen a case of byssinosis in which the late stage has developed without a preceding history of mill fever and long-continued cough; usually the stripper and grinder with developed byssinosis has been coughing fairly steadily for many years. Christie (1944) states that in emphysema the primary lesion is loss of elasticity, the most common cause of which is the stress and strain of cough or respiratory obstruction on the structures concerned in respiration.

Prevention

It was not until 1908 that attempts to control the dust were made. Obviously the ideal method is to ensure that the cotton dust does not escape into the atmosphere. This has not yet been found possible. Considerable improvements have been achieved by the introduction of dust covers and exhaust fans for machines in the cotton chamber and blowing rooms. Unfortunately today, even in the best equipped mills, at least one-third of the trash is carried into the card room in the laps; it is this third which is eliminated in the carding process. The sliver emerging from the carding engine is almost dust-free. The modern flat carding engine is not totally enclosed—there being considerable technical difficulties in achieving this. A recent attempt to do so was made by completely hooding the whole of the top of the carding engine,

and exhausting by means of a quarter horse-power motor fan—the air, drawn through the hood, being filtered before re-entering the room. The under-space of the carding engine is completely sealed off, and to clean under the engine the stripper and grinder has only to pull a small lever: the entire collection of dust is then swept away by the creation of a vacuum. This arrangement has greatly reduced the amount of dust in the atmosphere; 3·66 lb. were extracted from the hoods of 12 carding engines, through which 11,400 lb. of cotton had passed in 44 hours. These figures do not include the weight of debris from underneath the carding engine.

Many mills have insufficient air space, with the machinery crowded into too small an area. Greater air space means a greater dilution of the dust. Improved air conditioning, in conjunction with improved dust extraction, is necessary. Air conditioning must include a correctly controlled temperature, the right humidity, and adequate air movement —and these are also the best conditions for the cotton fibre.

A careful selection of operatives for the card room, and regular examination of existing workers, offer the best protection. All intending card-room operatives should be medically examined before engagement, and every effort should be made to exclude those types likely to be susceptible to the disease. Any operative who gives a personal or family history of asthma, bronchitis, hay fever, eczema, or recurrent urticarial attacks should be excluded from the card room. The general build and shape of the thoracic cage should be noted, and also the type of respiration. Mouth breathers are bad subjects. Malformation of the nasal bones, deflected septums, nasal polypi, enlarged tonsils, and extensive adenoid vegetations are all contra-indications for card room workers. A chest expansion below two and three quarter inches is suspect. All operatives are urged to practise nasal inspiration and to wear protective respirators. If a simple skin patch test for allergy could be obtained it would be a valuable help, both in the examination of intending card room operatives and as a diagnostic measure in suspected cases of byssinosis. To-day the disease is not nearly so common as formerly, but it still exists, and constitutes one of the main industrial hazards in the cotton industry.

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STUDIES IN OCCUPATIONAL MORBIDITY (1)

BY

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The influence of occupation on health has been recognized throughout the centuries. More than two hundred years ago Ramazzini, the father of industrial medicine, advised that in the examination of a patient it was of the utmost importance to ascertain the nature of his work. It is clear from his descriptions that he made himself intimately acquainted with the working conditions obtaining in a wide variety of employments. To-day it is recognized that an efficient industrial medical officer, in order to complete his contributions to the prevention and treatment of sickness and injury and to factory hygiene, should, ideally, acquaint himself with the precise nature of every occupation upon which members of his working population may be engaged, and as far as possible with the previous health and occupational histories of all employees brought under his observation.

Although an increasing interest has been taken since Ramazzini's time in the possible correlations between occupation and sickness, accurate information remained for a long time fragmentary. It was not until Farr initiated in this country the collection of figures bearing on occupational mortality that any degree of precision in our knowledge was attained. His researches in this field, like his other investigations, have been regarded as classic studies, and the policy which he originally formulated governed the compilation of data up to 1920. In the Occupational Mortality Supplement of the Registrar-General for 1921–3, an attempt was made to collect the statistics on an occupational rather than, as previously, a purely industrial basis. The differentiation is important because under the industrial allocation the mortality of some trades was heavily diluted by the inclusion of figures for other workers industrially related but not exposed to the same occupational risk. This was particularly true of workers engaged in occupations involving risk of silicosis. This alteration was, then, the first improvement in our more precise knowledge of occupational influence.

In the succeeding Supplement, based on the statistics for the years 1930–2, a still more important addition was made, for not only was the mortality of the male workers recorded, but also that of the wives of workers engaged in corresponding occupations. This information enabled a comparison to be made between direct and indirect occupational influence, because, if the excess mortality in an occupation was observable amongst males only, then the implication would be that the cause was purely occupational. If, on the other hand, both men and women experienced abnormal rates of mortality, then the high incidence could more legitimately be ascribed to the effects of a bad social environment. This idea of comparing the mortality of men and wives was not a new conception. Hay, who was interested in the relative influence of 'seed and soil' in tuberculosis, analysed similar statistics in Aberdeen many years ago. Nevertheless, the Registrar-General has considerably enriched our knowledge of medical statistics by his publication of the national data. From the information which he has compiled in this extremely valuable report, we learn that the seven occupations with the highest standardized mortality ratios (registered deaths expressed as a percentage of the calculated or expected number of deaths in the particular occupation) amongst males aged 20–65 were:

Tin and copper mine workers below ground	342
Sandblasters	304
Other metalliferous mine workers below ground	283
Stevedores	220
Slate miners and quarriers	168
Glass blowers and finishers (not machine hands)	160
Kiln and ovenmen (earthenware china, terra cotta)	157

In this list, six out of the seven specified occupations indicate the risks from silicosis, and in the remaining one the causal factor is probably a generally unsatisfactory environment.

We also find that there are instances in which married women have a mortality in excess of the average for all wives, but in which that of the males

in the corresponding occupation is a normal experience. This phenomenon is strikingly emphasized in the cotton industry, especially amongst textile spinners, the figures for men and wives being 105 and 124 respectively. The wives, or some of them, work in the mills and have the additional burdens of domestic responsibility.

The knowledge which we have gleaned from occupational mortality data is, on the whole, very instructive; but it does, nevertheless, lack precision for the following reason: the occupation entered on the death certificate is that at which the deceased worked prior to his death, but during his working life the man may have changed his trade or occupation several times, with the result that the one ascribed at death may be of an entirely different character from that which initially influenced his health. For this reason a study of occupational morbidity is much preferable to that of occupational mortality. In the main this has hitherto been a relatively unexplored field. Our knowledge has been chiefly derived from the admirable *ad hoc* investigations made by the scientific staff of the Industrial Health Research Board and available in the Board's publications, and also from the Annual Reports of H.M. Inspector of Factories.

Industrial managements in the past, with a few exceptions, have never been particularly interested in the sickness absence of their employees, despite the fact that the time lost and the sickness claims on benefit societies were of considerable magnitude, being in average pre-war years of the order of 26,000,000 working weeks with a sickness payment of something like £18,000,000.

It may be said that the impact of two wars, and the necessity of maintaining a high standard of output under the prevailing difficulties of transport and blackout conditions at work, made the supervision of the health of the workers a primary national consideration. Furthermore, the introduction of new types of industry arising out of war-time research, especially the manufacture of radioactive luminous paints, accentuates the importance of studying the health of those engaged in such processes. The introduction of new hazards in connexion with work arising out of atomic research will shortly necessitate the most watchful study of health and sickness in all persons at risk in Government or other laboratories and research centres and in related industries. It must be hoped that the health studies inaugurated during the initial war years will become a permanent policy of the industrial world generally. Certainly some of the more progressive industrial managements are alive to this necessity, and evidence of their interest is reflected in the extension and improvement of their sickness records, by which we have ourselves been greatly assisted in our preliminary studies in the area under review. The sickness absence form suggested by the Industrial Health Research Board (Report No. 85) has, in our experience in the factories under review during the past year, improved the value of records very considerably and rendered them more suitable for statistical analysis than those previously in use.

Data of Present Investigation

The present investigation, which is to be regarded as a pilot study, is based on the sickness recorded in a particular organization during 1944, in which 2,681 males and 717 females were engaged in either production or non-production work, and for whom relevant particulars of age were recorded. The population was composed of (*a*) workers present during the whole year, (*b*) leavers. There were no entrants. The leavers were regarded as being exposed to risk on the average for half a year, since the exact date of leaving was not recorded. Thus each leaver contributed half a unit to the yearly population. We say ' pilot study ' advisedly, because there were defects inherent in the data—such as a considerable amount of uncertified sickness, the nature of which was not specified. Even as regards certified illness there were imperfections in the records, because in many instances the specific cause of sickness on the medical certificate could not be deciphered by the Welfare Department and as a consequence the man's record card was merely marked with a ' C ' to indicate that he had a certificated absence. Accordingly in the present analysis certified illness was grouped under two headings: (1) certified and classified—i.e., the specific cause was known; (2) certified and unclassified—which represented men and women whose record card was merely marked ' C.' It must also be accepted that at the present time doctor's certificates allow only rough classification into main categories of illness. It is to be hoped that difficulties of this kind will in time be remedied in the interests alike of medical science, the worker, and the employer. The correct assessment of sickness and its causes, in so far as they may be related to working conditions, must depend very largely on improved certification and classification.

Production and Non-Production Groups—General Description

The two main groups of factory work can be roughly divided into ' non-production ' and ' production.' Staff and clerical categories must not be forgotten, but are not here considered. The production group were the

assemblers, fitters, welders, labourers, and inspectors. The non-production or auxiliary services included the police, fire brigade, cleansing department, transport, and electrical and machine maintenance. In this non-production group are included the elderly or unfit. Nevertheless in non-production work there are also adverse health factors. Among these should be mentioned changes of shift, necessity for working at week-ends, and, in some cases, long hours. Some factory maintenance has to be done at week-ends when the production side is idle. Working at these irregular hours involves missing the advantages of convenient works buses and trains. This of necessity adds to fatigue.

The production side, on the whole, have worked reasonable hours (about 48 per week) in the period covered. They did but little shift work. The work was often interesting and well paid.

Uncertified Sickness

The large amount of uncertified sickness is a feature of some importance. The labour management accept as a rule the word of a man when he states that his absence has been due to sickness. The reason for this is that the factory often retains its employees for long periods of their working lives. The management, because of this, are perfectly familiar with the good faith of their employees. This attitude, benign though it be, must be regarded as a serious obstacle to the detailed investigation of sickness absence.

Standardizing Sickness Rates for Age

Since sickness rates are generally a function of age—they increase with increasing age of the workers—it is necessary, when instituting comparisons between the total sickness rate in one organization with that in another or within the different departments of the same organization, or in comparing the total morbidity rate of males and females, to eliminate the influence of the age factor, or, as it is commonly called, to 'standardize for age.' The process of doing so is now generally familiar to students of public health and is described in all textbooks on vital statistics. In the present instance the population used as a 'standard' was the total working population of the factory in question, distributed in the following age groups:

Age group	Persons
14–20	210
21–25	215
26–35	654
36–45	1,103
46–55	843
56–60	196
61 plus	177
	3,398

It will be noted that the age grouping is slightly dissimilar to that used by the Registrar-General—i.e. 21–25 years instead of 20–24 years. The difference was due to a misinterpretation, but in future work the Registrar-General's age grouping will be adopted.

Percentage of Workers Absent

The percentage of employees absent through illness is stated with standard errors in Table 1.

TABLE 1
NUMBER OF WORKERS PER 100 TOTAL EMPLOYEES ABSENT THROUGH VARIOUS CAUSES

Sickness	Production				Non-production			
	Males		Females		Males		Females	
	%	S.E.	%	S.E.	%	S.E.	%	S.E.
Certified and classified ..	22·3	±1·16	19·3	±2·28	23·7	±1·14	23·4	±2·07
Certified but unclassified ..	18·9	±1·09	32·9	±2·71	24·3	±1·15	20·5	±1·98
Uncertified ..	55·6	±1·38	80·8	±2·27	54·1	±1·34	75·2	±2·12
No illness ..	25·1	±1·21	16·0	±2·12	27·4	±1·20	25·1	±2·12
Population ..	1,291		300		1,390		417	

Rates standardized for age.

The ratios for each category of illness are not additive, because in many instances employees had both an uncertified illness and a certified illness during the year; hence they are included in both categories. Thus, although the percentages represent the actual incidence for each type of sickness category, their summation would overstate the proportion of workers who had been ill during the year. As has been indicated, the percentage of workers who had uncertified illness is high. For males, the proportion was 55 per cent., with little divergence between the production and non-production departments. In this respect the statistical experience of females was much worse than that of males, as their absenteeism from this cause was as high as 80·8 per cent. in the production departments. There was little sex difference for specific causes of certified illness, the percentage for both sexes being of the order of 20 per cent., and, with the exception of females engaged in the production departments, the

TABLE 2
NUMBER OF OCCURRENCES OF ILLNESS PER 100 TOTAL EMPLOYEES DURING 1944 IN AGGREGATED PRODUCTION AND NON-PRODUCTION DEPARTMENTS.

Sickness	Production		Non-production	
	Males %	Females %	Males %	Females %
Certified and classified ..	28·0	22·9	24·8	24·6
Certified but unclassified ..	26·6	48·4	34·5	24·2
Total ..	54·6	71·3	59·3	48·8

Rates standardized for age.

proportion of the workers who had not been absent on account of illness during the year was of the order of 25 per cent.

Percentage of Occurrences of Certified Sickness.—The relevant statistics are stated in Table 2. The proportion of occurrences amongst males was fairly constant, being 54·6 per cent. in the production departments as compared with 59·3 per cent. in the non-production, but there was appreciable variation for females, the comparable rates being 71·3 per cent. and 48·8 per cent. The high incidence among the women engaged on production was due to unclassified sickness for which they produced a certificate. The slightly higher male figures for certified sickness in the non-production as compared with production groups probably reflects the employment here of men rendered unfit for more arduous occupations by disabilities in the 'chronic' category, etc.

Percentage Time Lost (Certified and Uncertified).—The percentage of possible working time lost on account of illness amongst employees engaged on production and non-production work is stated in Table 3. There was slightly more time lost in the production departments, the rates being 4·01 per

TABLE 3

PERCENTAGE OF POSSIBLE WORKING TIME LOST DURING 1944 FROM ILLNESS IN AGGREGATED PRODUCTION AND NON-PRODUCTION DEPARTMENTS

Sickness	Production		Non-production	
	Males	Females	Males	Females
Certified illness	3·12	2·61	2·97	2·39
Uncertified	0·89	1·19	0·89	1·18
Total	4·01	3·80	3·86	3·57

Rates standardized for age.

cent. for males and 3·80 per cent. for females, as compared with 3·86 per cent. and 3·57 per cent., but the differences are unimportant. On both types of labour the aggregate rate for females was lower than that for males, but this result was entirely due to their lower incidence of certified illness because, in point of fact, their lost time from uncertified illness was relatively greater than that for males.

Time Lost per Employee (Certified and Uncertified).—Another method of illustrating the effect of sickness on output is to express the days absent in terms of the working population and obtain the average time lost per employee. The necessary calculations were made and are shown in Table 4. It will be noted that both in production and non-production work, irrespective of type of sickness,

TABLE 4

AVERAGE NUMBER OF WORKING DAYS LOST BY SICKNESS PER EMPLOYEE DURING 1944 IN AGGREGATED PRODUCTION AND NON-PRODUCTION

Sickness	Production		Non-production	
	Males	Females	Males	Females
	days	days	days	days
Certified ..	9·37	7·45	8·93	7·20
Uncertified ..	2·69	3·54	2·68	3·55
Total ..	12·06	10·99	11·61	10·75

Rates standardized for age.

the women lost less time than the men. The average loss by men was 12·06 and 11·61 days respectively, the comparable values for females being 10·99 and 10·75 days. The lower averages for women were entirely due to their more favourable experience from certified illness, because from uncertified causes their loss was almost one day in excess of the average for men.

Average Duration of Certified Illness.—Although the time lost per female employee from certified illness was lower than that for the male, the occurrence of this sickness (as shown previously—Table 2) was relatively more frequent among women than among men in the production, and not very different in the non-production departments. Such facts would imply that, in the production departments at least, there existed an appreciable sex difference in the average duration of certified illness. The relevant statistics are recorded in Table 5, in which

TABLE 5

AVERAGE DURATION IN DAYS OF CERTIFIED SICKNESS DURING 1944

Department	Males	Females
Production	17·16 days	10·45 days
Non-production ..	15·06 days	14·75 days

Rates standardized for age.

it will be observed that the only divergence between averages for males and females existed in the production shops, in which the average duration of female illness was nearly 7 days shorter than that for men.

Sickness-Proneness

Since it was possible to obtain the number of certificates granted to each worker on account of sickness absence, a frequency distribution was made

for males and females who had been employed for the *complete year*. Leavers were thus excluded. The results are given in Table 6. It will be noticed

TABLE 6

FREQUENCY DISTRIBUTION OF EMPLOYEES ACCORDING TO NUMBER OF SICKNESS CERTIFICATES GRANTED DURING 1944

No. of certificates	Males (all ages)		Females (all ages)	
	Actual number	Expected number	Actual number	Expected number
0	1,656	1,652·07	359	356·68
1	588	598·65	136	141·11
2	203	193·40	43	40·76
3	57	59·95	11	10·32
4	17	18·19	3	2·43 } 13·42
5	8	5·45	—	0·55
6	—	1·62 } 7·55	—	0·12
7	1	0·48	—	—
	2,530	2,529·81	552	551·97

$\chi^2 = 1{\cdot}107$, $n = 3$, $0{\cdot}8 > P > 0{\cdot}7$ $\qquad$ $\chi^2 = 0{\cdot}362$, $n = 1$, $0{\cdot}7 > P > 0{\cdot}5$

that the distribution in each instance is of a skew character. Of the 2,530 males, 1,656 had no certified illness and 9 workers had as many as five or more illnesses each during the year. For females the number who did not have a certified illness totalled 359, and 3 women were ill on four occasions. Assuming that all the workers were equally likely to contract an illness requiring a certificate, a theoretical distribution was evaluated on the basis that the data were in accord with a Poisson series. The resultant values of this theoretical distribution did not justify the hypothesis of equal liability. Next, it was assumed that some workers were more liable than others to contract illness or to ' go sick '; that there may, in fact, exist a ' sickness-proneness ' as well as the generally recognized ' accident-proneness .' To test the validity of this assumption a negative binomial curve was fitted to the data, and the expected distributions for males and females arising from this hypothesis are stated in the third and fifth columns of table 6. It will be seen that there is a very close correspondence between the fact and the theory. For males the value of χ^2 is 1·107 and for N=3, P lies between 0·8 and 0·7 which indicates that, on the basis of our hypothesis of unequal liability, differences as great or greater than those now observed between the actual and predicted values would arise in at least 70 per cent. of trials by mere chance. For females the concordance was equally satisfactory, the value of χ^2 being 0·362 and for N=1 P lies between 0·7 and 0·5.

Such ' sickness-proneness ' might be due, on the one hand, to a too-ready ' habit of going sick ' in the absence of demonstrable disease, or, on the other, to chronic illness with exacerbations necessitating frequent absences. It is clearly important to separate these causes. Bashford (1942), although not under this heading, discusses cases of what might well be called ' sickness-proneness ' in post-office employees:

> ' Over and over again he (the medical officer) will find some such factor as groundless anxiety, thwarted or seemingly thwarted ambition, some personal antagonism, real or fancied, to a particular job or fellow-worker or foreman or office superior; and he will be able to make an adjustment which results in an immediate and permanent alteration in the sick record. Or he may find some factor of irresponsibility, not of malingering in any serious sense, but of a too light-hearted taking of a day or two off for medical or semi-medical reasons. Few people, and especially young people, memorize their own sick records; and many when confronted with them in black and white are genuinely surprised by their extent; often a complete alteration is the result. If there is no change and no definite physical or psychological cause is discovered for repeated minor sick absences, a kindly intimation that if the record continues as in the past the question of retirement or discharge on medical grounds will arise may have a considerable effect. This was illustrated in a group of workers on whom I have previously reported. Over about four years this group of 40 people, mostly young, had incurred between them 736 separate sick absences, totalling 6,194 days; after receiving the intimation described, these 40 people during the next 6 months only incurred 54 days' sick absence, their 6-monthly average of illness dropping from 19 days a head to 1·3. It would be unfair to describe supervision of this sort as medical police-work in any vindictive sense, since it was clearly of benefit not only to the departments but to the workers concerned; and it may be that such supervision may prevent the development in later years of a valetudinarian outlook on life much harder to combat. In any large staff there will also probably be cases in which the real reason for continued minor illnesses is a fundamental dislike to the particular occupation. In such cases, medical advice to seek some other mode of life is probably in the truest interest of the employee.'

The records of the 8 cases among male workers with five instances of certified illness in the year, 1 male worker with seven instances, and the 3 female cases with four instances of certified illness in the year were studied in closer detail with the following results.

Of the males, 7 were in the chronic illness group, but 2 suffered from that factor of social irresponsibility to which Bashford drew attention. Among the 7 chronic illnesses there were 2 cases of pulmonary tuberculosis, 1 of chronic nephritis, 1 of old age and bronchitis, 1 of chronic bronchitis and asthma, and 2 of psychoneurosis.

One of the psychoneurotics had claustrophobic symptoms since being subjected to 17 hours' continuous dive-bombing. His symptoms improved when he was in the open air. Many psychoneurotics are at their best in open-air work.

The two cases of social irresponsibility form a special group. One of them, owing to unstated cause of absence, was interviewed by the labour manager. He gave as a reason 'rheumatism in the neck,' although the foreman saw nothing wrong in the manner in which he was doing his work. He accepted an appointment for treatment for which he never turned up. Almost immediately, he had eight weeks off work with 'gastric catarrh.' On return to work he stated that the symptoms of this had been present for six years and consisted of swimming in the head, poor appetite, and epigastric pain unrelated to food. He had never had hospital investigation for these symptoms. He was again interviewed after a further absence from work. This time the symptoms were given as 'melancholy agitation with irritability.' He then worked at a neighbouring factory where he had a long spell away because his wife had left him. He was a prominent and regular member of a dance band.

The other case had a variety of diagnoses on his medical certificates. On one occasion he refused work because of lumbago. This was accepted, even though he also had no desire for treatment to enable him to do his work. He neglected to use protective equipment and developed 'arc eyes' due to welding. When he subsequently had dyspepsia, he attributed this to having to wear protective equipment.

The above two cases would not be re-engaged by the labour manager on any conditions. Nevertheless, it is only fair to state that the industrial efficiency of this type must depend to some extent on the quality of the foremanship in the factory, and there is evidence that the second case developed a grudge against the firm, having previously been a satisfactory employee for many years.

Of the 3 females with multiple absences there was 1 case of recurrent bronchitis, 1 of recurrent fibrositis, and 1 case of social irresponsibility.

This last case was that of a single girl in billets with no arduous duties. She lost time with recurrent dyspepsia and a severe cold. She appeared to be apathetic, but in the best of health. Her long-standing dyspepsia had never had hospital investigation, neither did she desire it. Her absences were so suspicious that she came before the absentee tribunal. She was discharged from the firm and would at no time be re-engaged.

Among the 12 cases considered under this heading, there were thus 3 cases of 'social irresponsibility'—2 male and 1 female. The remainder had chronic or recurring physical disabilities. We have, unfortunately, no means of ascertaining what proportion of the cases of recurrent uncertified sickness should be attributed to 'social irresponsibility' or to a too ready utilization of minor symptoms or maladjustments to the working environment.

In further communications it is hoped to take up such questions as the incidence of main types of illness occasioning absence in the same factory, and, so far as possible, to correlate these with age, sex, length of employment, trade, season, etc.

Summary and Conclusions

The investigation was based on the absenteeism due to sickness amongst 2,681 males and 717 females engaged in the production or non-production departments of a particular industrial organization during the year 1944. The main conclusions are:

1. Although the occurrence of certified illness was relatively more frequent amongst women than amongst men in the production departments, its average duration was approximately 7 days shorter.
2. The percentage of possible time lost on account of certified sickness was lower for women than for men in both the production and non-production shops, but their rates for uncertified illness were greater.
3. There is evidence to indicate, both amongst men and women, that in the case of certified illness there were some workers who had a 'sickness-proneness' due either to chronic or recurring physical disabilities, or to social irresponsibility. It is reasonable to suppose that 'sickness-proneness' will also occur in the uncertified group.
4. The rates of uncertified illness in the industry under review are high and suggest the need for a reconsideration of policy in respect of certification requirements. This would be in the interests alike of the worker, the employer, and of future investigations of occupational morbidity and its causes.
5. The sickness absence form (Report No. 85) devised by the Industrial Health Research Board has greatly improved the value of the records now being put at our disposal for future use, as it has helped to avoid some of the defects inherent in the data on which the present analysis was based.

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THE HAND OF THE PLANT POTTER: A STIGMA OF THE MARKET GARDENER

BY

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Since the days of Hebra and Joseph Bell the detection of a man's occupation from visible signs of disease has had a singular fascination for the clinician. This note adds another occupational stigma, hitherto unrecorded, to those already recognized.

A man of 59 had been a market gardener for over thirty years. An attack of influenza in 1926 was followed by migratory rheumatic pains of moderate severity, which had interfered with his work but little until a few months before he consulted me in July, 1946. He then showed arthritic changes practically limited to the hands, a not infrequent infirmity in market gardeners, which is attributable to the local exposure to damp. In place, however, of the common finding in arthritis of the hands of ulnar deviation at the metacarpo-phalangeal joints, there was in his right index finger 30°, and in his left 25° of ulnar deviation at the proximal interphalangeal joint (fig. 1). Radiographs of the hands (fig. 2) show clearly this arthritic change and the associated lateral subluxation. The explanation is evident from fig. 3. An important part of a market gardener's work is the potting of plants. This entails pressing the soil down with the thumbs and fixing the pot with the index fingers; thus, pressure is applied to the radial side of the distal phalanges of the index fingers, and in joints weakened by arthritis the deformity described readily occurs. There was no accompanying hyperkeratosis.

Where, in established disease, unusual signs are found, the possibility of their being an expression of the patient's employment must always be investigated.

FIG. 1.—Hands showing arthritis (note swelling of wrists and of interphalangeal joints of the right ring and little fingers and the left middle finger) and the ulnar deviation (right = 30°, left = 25°) at the proximal interphalangeal joints of the index fingers.

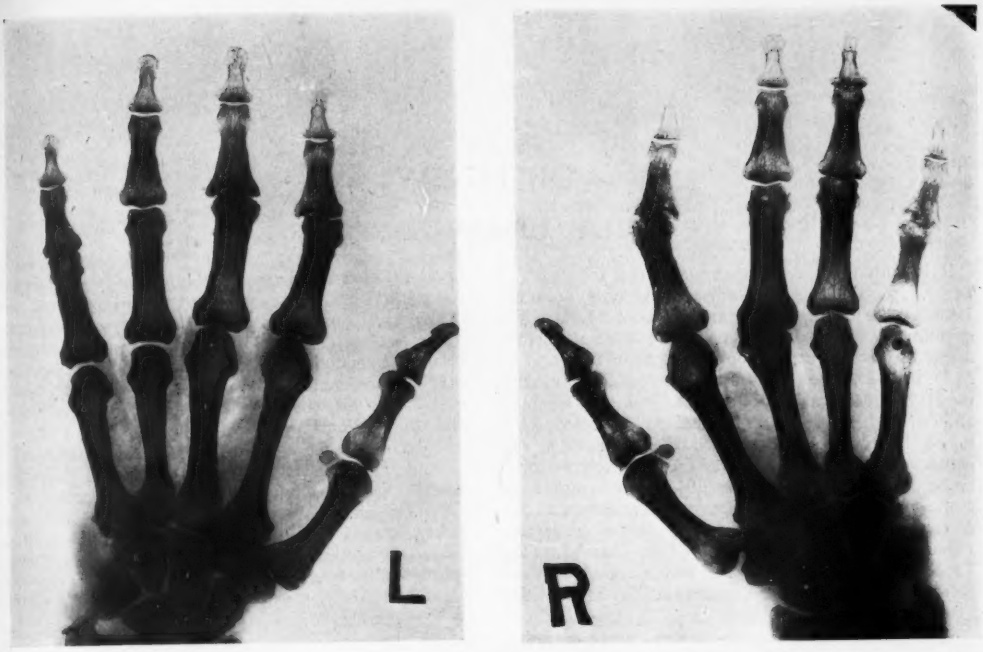


FIG. 2.—Radiographs showing arthritic changes and subluxation in the deformed joints.

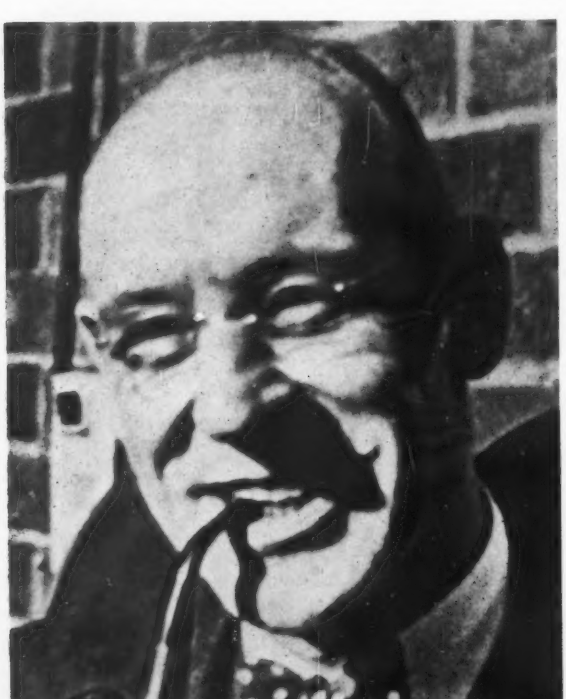
FIG. 3.—Shows the position of the patient's hands in potting.

OBITUARY

LEROY UPSON GARDNER

It is with deep regret that we record the death of Leroy Upson Gardner at Saranac Lake on October 24, 1946, at the comparatively early age of 57. He was born in New Britain, Connecticut, and began his medical career at Yale, where he took his B.A. in 1912 and his M.D. in 1914. He then went to Boston and worked in the Havard Medical School at the Boston City Hospital, and during 1916–17 he was instructor in pathology. He joined the U.S. Army Medical Corps in 1917 as a lieutenant, but in 1918 he became assistant professor of pathology at Yale. Then in 1919 he was appointed pathologist to the Trudeau Foundation at Saranac Lake, and subsequently and successively director of the Saranac Laboratory in 1927 and director of the foundation and Trudeau School in 1938. He was a member of the corresponding committee on silicosis of the International Labour Office at Geneva, a Fellow of the American Association for the Advancement of Science, a member of the American Association of Pathologists, a director of the National Tuberculosis Association, and a member of the Council on Industrial Health of the American Medical Association. He received the Trudeau Medal in 1935 for his work on the pathology of tuberculosis and the relationship between tuberculosis and silicosis. In 1940 he received an honorary M.S. degree from Yale, and in the same year won the William S. Knudsen Award for his research on the control of silicosis.

To the many Englishmen who have visited Saranac Lake, he will always be remembered for his great hospitality, courtesy, and kindness. The picture which we reproduce is characteristic of him with his pipe and was taken shortly before his death. He is most famous for his work on silicosis, which started when he was a medical student. He sought an answer to the question : 'Why are some stone cutters in the Barre, Vermont granite quarries highly susceptible to tuberculosis; while in the near-by Proctor, Vermont marble quarries the cutters are not similarly affected ?' He began his investigations in 1922, and in the next year published (*Amer. Rev. Tuberc.*, 1923, **7**, 344) the results of his classic experiment with the finely divided powder of carborundum (silicon carbide), which failed to produce silicosis despite the sharp-edged nature of its particles. He soon became an international authority on the subject. He reported unequivocally that the inhalation of metallic aluminium and hydrated aluminium oxide—XH 1010—protects animals against the development of silicosis (*J. industr. Hyg.*, 1944, **26**, 211). This finding necessitates a therapeutic trial in man.



At the time of his death, Dr. Gardner was engaged on an expansion scheme for his laboratory and the development of a million dollar medical centre at Saranac Lake; he had already raised more than a hundred thousand dollars for the project. He was also interested in the expansion programme planned for the Trudeau Sanatorium. He will be sadly missed in the fields both of silicosis and tuberculosis.

Dr. Gardner leaves a widow, Carabel McKenzie, whom he married in June, 1915, and two daughters, Mrs. Benjamin Downs of Washington, D.C., and Mrs. F. Levering Neely of Atlanta, Georgia.

K. M. A. P.

BOOK REVIEWS

NURSING IN COMMERCE AND INDUSTRY

Bethel J. McGrath

The Commonwealth Fund

(Geoffrey Cumberlege. Oxford University Press. 1946. Pp. 356. 16*s*. 6*d*.)

Mrs. McGrath says in her preface that the most important ingredient in the making of an industrial nurse is a superior nurse. If such a nurse is looking for first-class guidance in her special subject, here it is. It is unlikely that any earlier book has been able to offer her so much of value in one volume, and it is to be hoped that the price will not be too much for her. The scope is so wide that if a nurse were to be employed by a small firm and told she was expected to organize an efficient first aid and health service for the factory, with the minimum of qualified medical aid, there could hardly be any situation in which she need feel at a loss. After a chapter on the history of industrial nursing, there is an invaluable one on the general organization of an industrial undertaking, which acts as an introduction to a third on the relationships of the nurse to employers and employed; to win the confidence of both may at first be the hardest part of a nurse's task, and the author offers good sense and sound psychology, illustrated with practical examples and some delightful epigrams. The chapter headings suggest that the subject is treated on general lines without regard to practicalities, but the reverse is true. Under such a heading as 'physical facilities of the industrial health service' is to be found a discussion of the most appropriate name for the factory medical department, the space and layout it needs, and its construction and lighting. Under the heading of 'nutrition' come such practical matters as 'food fads,' the organization of canteens, and the amount of furniture required. 'Mental hygiene' is the heading of a chapter dealing largely with misfits and people with financial or family worries, who may behave unusually and need special help. There are sections on occupational and non-occupational diseases and accidents, on problems peculiar to women in industry, and on the quick detection of common infectious diseases and their control; the pages on the problems of the tuberculous are noteworthy. The last chapters deal with records and reports, with workmen's compensation, and with welfare activities; but these are written from an American viewpoint and do not strictly apply to British methods and legislation. There are useful appendices on surgery equipment, and standing orders for nurses to cover certain specific injuries and contingencies. No book could be more confidently recommended to a nurse in industry, whatever her experience or status, to those who are considering entering the field after their hospital training is over, or to industrial medical officers in search of fresh ideas to enhance the efficiency of their works medical department.

J. N. Agate.

HANDBOOK OF THE SCIENTIFIC MANUFACTURERS' ASSOCIATION OF GREAT BRITAIN, LTD.

This privately published handbook gives information about the Officers of the Association, its aims, government, and organization. There follows a short review of the growth of the British scientific instrument making industry from the time of Leonard Digges, who first made a theodolite some time before 1571; many names famous amongst chemists and physicists appear. The bulk of this slim volume is made up of an alphabetical list of the forms of scientific apparatus manufactured by the member firms of the Association, and of a collection of trade announcements of these various firms. The manufacturer who specializes in making any particular piece of physical, chemical, medical, or other laboratory apparatus can be traced at a glance. This should greatly assist research and teaching departments. The handbook appears to have a restricted circulation but inquiries may be addressed to the Association's Secretaries, Messrs. Binder, Hamlyn and Co., River Plate House, 12/13 South Place, London, E.C.2. *J. N. Agate.*

HEALTH AND SOCIAL WELFARE 1947

Advisory Editor, The Rt. Hon. Lord Horder, G.C.V.O., M.D., B.Sc., F.R.C.P.

(Todd Publishing Co. Ltd., London. Pp. 527. Price 25*s*.)

This annual reference book has again made its appearance, and the information in it provides much which must give thinking people food for reflection. It is common knowledge that there is a rapidly growing horde of civil servants, and this book gives some indication of the extent to which this parasite mass is infiltrating the sphere of health and social welfare. It would be valuable information if, in future years, we could be told the number of forms which each of these departments issues. There are some 64 pages devoted to lists of officially appointed committees of various varieties. We can learn that the Medical Advisory Board of the Royal Air Force has not met since the outbreak of war; and can, therefore, appreciate the excellent advertisement value of these committees both to departments and individuals. We might be able better to assess the value of each and all of them if we were informed how often they met and were given the attendance of individual members. Some names appear so frequently that either their owners must be whole-time committee men, or else the committees serve no useful purpose. We take special interest in three of these committees related to industrial medicine—the Industrial Health Advisory Committee, the Industrial Health Research Board, the National Advisory Council under the Disabled Persons (Employment) Act, 1944; their personnel is given at length, but there is no evidence that any of them have ever contributed anything useful to the community. We would ask our readers seriously to consider them. Doubtless their service is confidential, and may be they are useful scapegoats in adversity.

Of the book itself, its format is the same as in previous years, with the same degree of accuracy and inaccuracy. The Medical Research Council is still divorced throughout from its sister organization, Department of Scientific and Industrial Research, and while the *Lancet* has been included in the list of medical periodicals, the Editor of the *B.M.J.* is not yet included in the section of the book

Who's Who. Perhaps the best feature in the book is the extremely able article on 'The duties of a medical officer in a large factory,' by Dr. A. J. Amor, and we would advise all our readers interested in this subject to read it. To those interested in government departments and their committees, the book as a whole will be a useful reference volume. *K. M. A. P.*

LA SILICOSIS PULMONAR

By Hugo Dooner

(Medical Officer to the Department of Industrial Hygiene of the San Vicente Hospital, Santiago)

This book is a review of silicosis and is written in Spanish; it contributes very little that is new or original to our knowledge of the subject. The worker is at present in the Department of Industrial Hygiene in Santiago and was at one time medical Officer to a copper mine in Chile. He uses a classification of Pendergrass and Pancoast slightly modified to meet local requirements, and adds cases complicated by tuberculosis as an appendix. He divides his own workers into three groups; group 1, those with little or no physical incapacity and with little or no fibrosis, men whom he examined once a year; group 2, those with greater disability and more fibrosis, in whom he ordered a change of work and monthly examination; and group 3, those with marked fibrosis and gross incapacity, who were so badly affected that they were given life pensions. He reports at length the literature and gives an extensive bibliography. He discusses various forms of apparatus for counting dust particles and stresses the value of Greenberg and Smith's impinger. *G. C. P.*

BRITISH AND FOREIGN OFFICIAL PUBLICATIONS

MINISTRY OF LABOUR AND NATIONAL SERVICE. INTERIM REPORTS OF THE JOINT ADVISORY COMMITTEE OF THE COTTON INDUSTRY.

1946. London : H.M.S.O. Pp. 18. 3*d*.

The first of these reports makes recommendations about sanitary accommodation, washing facilities, accommodation for clothing, medical and welfare services, decoration and vacuum cleaning. Sanitary accommodation should be made to conform to good modern standards as regards type, accessibility, lighting, and ventilation. Washing accommodation should be provided on the scale of one wash basin for each 20 persons employed, adequate provision being made for each work room ; foot baths are necessary for mule spinners; and for these and others who work in hot conditions shower baths are desirable. Individual lockers in the workroom or changing-room are regarded as the best provision for clothing. For drying wet clothing a heated cloakroom is sufficient. In every mill there should be a first-aid room, a rest-room, and a first-aid attendant: the latter can be employed for other duties also. The increased use of canteens should be encouraged. Meals should not be taken at the work-place. All welfare amenities should be effectively supervised. Vacuums should be used for cleaning machinery and floors.

The second report deals with the control of dust in card rooms. Existing blowing-room machinery should be overhauled so that dust extraction is efficient. Leakage of dust from opening machinery should be prevented by the enclosure and exhaust ventilation. Pneumatic systems should replace manual methods in certain operations. Stripping should be done strictly as recommended in the 1932 report on card-rooms. The importance of proper maintenance of stripping plants is emphasized. *T. Bedford.*

ARTIFICIAL SUNLIGHT TREATMENT IN INDUSTRY.

Dora Colebrook. *Industrial Health Research Board Report No.* 89. H.M.S.O. 1946. Pp. 64. 1*s*.

This is the report of an inquiry into the effects of ultra-violet light treatment on the health of clerical and industrial workers. It was carried out in an office, a factory and a coal mine during the winter months of 1944 and 1945. Sickness absence, duration of colds in clerical and factory workers, and injury and total absence among miners were the criteria used. In each group, one set of workers were treated with the full range of rays from mercury arc lamps, while there were two control sets, one irradiated with similar lamps from which the shorter ultra-violet rays were cut off, and the other untreated. In the clerical and factory workers there was no difference between the treated and untreated groups with regard to sickness absence, but in respect of colds there was actually a significant advantage to the untreated subjects. In the case of coal miners, both groups of treated men had a significant advantage over the untreated controls in respect of sickness and total absence. There was, however, evidence that the previous health of the untreated group had not been so good, and they were not a random sample. In all groups the person treated with the shorter ultra-violet rays did not differ significantly from those irradiated but not receiving these rays. This report is a valuable contribution in 'debunking' a form of treatment which was becoming very popular in industry with no evidence to support it. *K. M. A. Perry.*

ABSTRACTS

(The abstracts are divided into the following sections: toxicology; industrial physiology; industrial lung disease; industrial psychology; industrial dermatitis; general. After each subsection of abstracts follows a list of any articles that may have been noted but not abstracted.)

TOXICOLOGY

Arsine Poisoning. HAWLICK, G. F., and LEY, E. B. (1946). *Occupat. Med.*, **1**, 388.

This case illustrates a frequent but often unrecognized hazard. Working in a poorly ventilated place, a man was engaged in cleaning an iron water jacket by pouring dilute commercial hydrochloric acid through the pipes of the jacket. Three hours later he noticed tightness of the chest, nausea, and vomiting. One hour later blood-coloured urine was voided: laboratory examination showed haemoglobinuria. Jaundice developed 16 hours after exposure. On the fourth day the red blood count fell to 1,750,000 cells per c.mm. of blood. Recovery took place within 16 days.

The hydrochloric acid contained 0·35 g. of arsenic per 100 c.cm., which had been added as an inhibitor to prevent the corroding of metal by the acid. The exact form of the inhibitor could not be determined, but it is known that a mixture of sodium arsenate and aniline hydrochloride are used for this purpose.

T. A. Lloyd Davies.

A Clinical Syndrome Following Exposure to Atomic Bomb Explosions. KELLER, P. D. (1946). *J. Amer. Med. Ass.*, **131**, 504.

Information was obtained about 21 patients who were admitted to the Osaka University Hospital in late August and early September, 1945, suffering from an alarming malady designated by the Japanese as 'atomic bomb disease.' The selected patients did not include those receiving severe blast injuries or extensive external burns at the time of the explosion. It is to be remembered that these people were not hospitalized until, on an average, one month after their atomic bomb experience. The average day of death for the 5 fatal cases was 26 days after the bombing. Those who survived required long periods of hospitalization before their recovery was sufficient to warrant a hospital discharge.

The data on these few patients seem to indicate that the possibilities of developing this syndrome is not significantly affected by distance from the centre of the explosion as long as one is within a 2,000 meter radius. It is undoubtedly significant that only one patient is known to have been outdoors when the explosion occurred, and, therefore, people inside buildings were more apt to suffer from the delayed effects of atomic bombs provided they survived the initial effects. The delayed malady to some degree results from a generalized disturbance in human physiological function, but the effects can be attributed principally to destruction or suppression of elements of the haemopoietic system (mainly granulocytes and thrombocytes) and to disturbance in liver function. The former effect produces a leucopenia (principally a granulocytopenia), thrombocytopenia, increased bleeding time, and haemorrhagic tendencies, with a resulting anaemia, fever, and weakness. The latter effect on the liver produces an albuminuria, tyrosinuria, hypoproteinaemia, positive indirect van den Bergh reaction, jaundice, and fever. The sedimentation rate was rapid. The similarity of this illness to that following excessive irradiation of the body with *x* rays is striking.

A. Thelwall Jones.

Radiation Sickness in Nagasaki. TIMMES, J. J. (1946). *U.S. Naval med. Bull.*, **46**, 219.

A study was made of the radiation effects resulting from explosion of the atomic bomb approximately 33 days after the initial blast. During the first few days of the investigation an average of 20 new cases were admitted to the hospital, but within two weeks the admission rate dropped sharply to one or two new cases daily. Tests of the area and victims failed to reveal any significant amount of radiant energy remaining. No patient was found who had been beyond 3 kilometres from the centre of the explosion area. The average newly admitted patient complained of fever, malaise, loss of appetite, bleeding gingivae, and haemorrhagic diarrhoea. Two cases of necrosis of the mandible and one case of noma were seen. The teeth were generally loose and easily removed by hand. Patients revealed true forms of radiation sickness, and only a few mild *x*-ray skin burns were seen. There were many cases of alopecia; some of the victims began to lose their hair 4 or 5 days after the explosion, and others at about the third week; none exhibited complete loss of hair, and the permanency of the loss is speculative. The principal effect of the radiation was a marked degree of depression of the bone marrow. Most of the cases showed an aplastic type of anaemia. A number of white blood cell counts under 1,000 were seen, and in some cases the white blood cells completely disappeared before death. One patient with 400 cells per c.mm. recovered. Smears showed a great decrease in the number of thrombocytes, and petechiae and gross haemorrhages were commonly seen. Bleeding times of over 45 minutes were found. Urine analysis frequently revealed albumin, casts, bile, and red blood cells.

Treatment was limited by short supplies, but penicillin and plasma had beneficial effects. Liver extract seemed to benefit a few patients, but in general was not very effective. Pentnucleotide was used in limited amounts, namely 3 ml. three times daily, in severe cases, and in each one of the patients a progressive rise of the white blood cell count appeared in 24 hours.

A. Thelwall Jones

Carbon Tetrachloride Poisoning : A Fatal Case following Accidental Ingestion of Carbon Tetrachloride. CAIRNS, F. J. (1946). *New Zealand med. J.*, **45**, 176.

The details are reported of a fatal case caused by the accidental swallowing of approximately 2 oz. of carbon tetrachloride. A man of 28 during an alcoholic debauch drank from a gin bottle containing clear fluid which was carbon tetrachloride. Next day he had nausea, abdominal pain, uncontrollable vomiting, diarrhoea, and joint pains. Hoping to obtain relief he consumed further alcohol but his symptoms increased; he developed a deepening jaundice with anuria, and died 6 days later. Necropsy showed bronchopneumonia, cloudy swelling of the kidney, and central hepatic necrosis. The fatal outcome was thought to be influenced by the consumption of alcohol, in the presence of which carbon tetrachloride is more readily absorbed. The fatal dose by ingestion cannot be stated with accuracy, but other authors are quoted as recording death after 2 c.cm. and 4 c.cm. Delay in arriving at a causal diagnosis in this case prevented the use of methionine which is recommended as a specific therapeutic remedy. *J. L. Lovibond.*

Death and Illness from the Use of Carbon Tetrachloride. MCGILL, C. M. (1946). *Northwest Med.*, **45**, 169.

Six cases of carbon tetrachloride poisoning which occurred from using this substance without adequate safety precautions are described. With the possible exception of benzol, carbon tetrachloride is the most toxic solvent used in industry and produces acute haemorrhagic nephritis and toxic hepatitis, usually by inhalation. The author emphasizes that, being an excellent solvent with non-inflammatory properties, it tends to be used too often both in industry and in the home without appreciation of its dangers. A reminder is given to physicians associated with industries of their responsibility in the education of employers. It is suggested that this and other solvents should be kept under lock and key and issued only on requisition so that a definite control system may be maintained. *J. L. Lovibond.*

The Toxicology of 1,2-Dichloroethane (Ethlyene Dichloride). V. The Effects of Daily Inhalations. HEPPEL, L. A., NEAL, P. A., PERRIN, T. L., ENDICOTT, K. M., and PORTERFIELD, V. T. (1946). *J. Industr. Hyg.*, **28**, 113.

The toxicity of 1,2-di-chloroethane has been studied by exposing animals for 7 hours daily, 5 days a week, to concentrations of 1,000, 400, 200, and 100 parts per million of the hydrocarbon in air. Groups of animals of various species were exposed simultaneously in a closed chamber measuring 4 ft. × 4 ft. × 6ft., air being drawn through the chamber at a rate sufficient to renew the air every 7 minutes. At a concentration of 1,000 p.p.m. almost all the rats rabbits, and guinea-pigs died after a few 7-hour exposures, but cats and dogs were more resistant, some of them surviving 55 to 66 days' exposure. One monkey died after 2 exposures, and a second after 32 exposures. Dogs appeared unaffected after 8 months' exposure to 400 p.p.m., and a third of the rabbits, guinea-pigs and rats survived 12 to 94 exposures. A concentration of 200 p.p.m. was well tolerated by 2 monkeys and 5 rabbits, but it killed half the guinea-pigs and rats after 1 to 115 exposures. At a concentration of 100 p.p.m. all the 39 rats exposed survived after 74 or more exposures.

Pathological examination of the animals exposed to 1,000 and 400 p.p.m. showed occasional pulmonary congestion, renal tubular degeneration, and fatty degeneration of the liver. The data, therefore, indicate that dichloroethane is one of the more toxic of the commonly used chlorinated hydrocarbons. *H. M. Vernon.*

Ventricular Fibrillation Induced by Hydrocarbons and Epinephrine. CHENOWETH, M. B. (1946). *J. Industr. Hyg.*, **28**, 151.

It was shown by Levy in 1911 that the cause of death observed under chloroform anaesthesia may be ventricular fibrillation, and it is generally considered that in order to induce this condition it is also necessary to have a high concentration of epinephrine in the blood. Some of the solvents employed in industry, such as ethyl chloride, carbon tetrachloride, petroleum ether, and benzene, are likewise capable of sensitizing the heart to the action of epinephrine. The author has extended these observations and made some of them quantitative. Dogs were used in the tests, and it was found that heptane and benzene were the most powerful agents, for a concentration of 5% in the inhaled air regularly permitted the induction of fibrillation by 0·01 mg. per kg. of epinephrine injected intravenously. Gasoline was nearly as effective, but methane and butane usually required higher vapour levels and higher doses of epinephrine (0·04 mg. per kg.). A number of electrocardiagram records are reproduced in support of these statements. Other hydrocarbons—all of them lipolytic in their properties—were likewise found to have the action described.

The practical implication of these observations is considerable. It is known that apparently trivial accidents and quarrels may render individuals highly susceptible to ventricular fibrillation for some minutes if the discharge of epinephrine is added to exposure to the substances mentioned. Aeroplane and armoured vehicle interiors, where the combination of gasoline vapours and emotional stress frequently co-exist, are particularly dangerous. *H. M. Vernon.*

Hydrogen Sulphide Poisoning : Report of Two Cases, One with Fatal Outcome, from Associated Mechanical Asphyxia. FREIREICH, A. W. (1946). *Amer. J. Path.*, **22**, 147.

Two men, while attempting to clean out a septic tank to which concentrated sulphuric acid had been added, suffered from smarting of the eyes, respiratory difficulty and unconsciousness. One succumbed, and at necropsy showed greenish cyanosis of head and face, pulmonary oedema, and subpleural haemorrhages, together with burns from partial immersion in the acid. The dangers inherent in such procedures are stressed as a warning for public health protection. Hydrogen sulphide is a very toxic gas. In concentrations at which the characteristic odour is apparent its toxicity is not great, but when higher concentrations are reached (1 mg. per litre) rapid and fatal poisoning may occur. This danger is enhanced by the fact that the gas in higher concentrations paralyses the olfactory nerves, rendering the subject unaware of his impending peril. Hydrogen sulphide poisoning occurs also in industry, for example in gypsum and sulphur mining, in the production and refining of sulphur petroleum, in oolythic limestone excavating, and in the manufacture of certain chemicals, dyes, and pigments. There is only one satisfactory medico-legal test of its presence in the body, namely the discolouration of lead acetate paper applied to the cut surface of muscles or lungs.

The determination of hydrogen sulphide concentration in the blood is impracticable because the speed of its decomposition is more rapid than the test. Neither is spectroscopy a reliable expedient because the gas is oxidized at once by the blood oxyhaemoglobin and little or no sulphaemoglobin is formed. *J. L. Lovibond.*

Chronic Phosphorus Poisoning. HEIMANN, H. (1946). *J. Industr. Hyg.*, **28**, 142.

In Great Britain phosphorus necrosis of the jaw practically disappeared shortly after the introduction of the legislation which outlawed the manufacture of the yellow phosphorus match, but during the war 1914–18 cases of the malady reappeared, as phosphorus was being used in chemical smoke screens and incendiary bombs; also fresh cases appeared during the war 1939–45. The author gives a detailed review of the literature of phosphorus poisoning, including 57 references. He points out that the most typical characteristic of chronic phosphorus poisoning is necrosis of the jaw. Other bones may be involved, there being a generalized reaction of the periosteum producing a hyperostosis. There is first a deposition of calcium salts, followed by a resorption of these salts leading to bone atrophy. As a result, fractures of the weight-bearing bones frequently occur.

The author describes three recent cases of phosphorus poisoning involving the jaw bones. Case 1 relates to a 40-year old man who had been employed for 8 years in the department of a plant in which yellow phosphorus was converted into red phosphorus. After experiencing joint pains, and especially jaw pain in the lower molar region, he had a portion of the lower jaw removed surgically. Later the right side of the mandible became involved, and sequestra were removed as they formed. A year after the onset of the disability the condition became quiescent. Case 2 relates to a man aged 25, who developed a cyst-like area near the left retromolar fossa, and subsequently a corresponding area on the other side of the jaw. Drainage was instituted, sequestra were removed as formed, and a year after the onset the diseased areas of bone were completely healed and the bone had regenerated. Case 3 relates to a man aged 35, who had been employed in packing yellow phosphorus for 13 years. The disease began in the right maxillary first molar area, and shortly after in the corresponding area of the left maxilla. In spite of surgical treatment the process extended to the upper palate, and the patient lost a large portion of that bone. This resulted in fistulous tracts leading from the mouth into the nose and nasal accessory sinuses, and the condition was still active 18 months after its onset. *H. M. Vernon.*

Thioglycolic acid poisoning in Connexion with the 'Cold Wave' Process. *Cotter, Lawrence H.* (1946). *J. Amer. Med. Ass.*, **131**, 592.

A few years ago a process of hair curling was put on the market known as the 'cold wave.' There are variations in the basic solutions as put out by different manufacturers, but thioglycolic acid in dilutions up to 5% is a constituent of all those investigated. Cases in which a toxic reaction has been observed appear to be rising. An outfit for home use has been on the market, and it should be recognized as a danger in unskilled, and even sometimes in skilled hands. Persons suffering from allergies and anæmias are the most likely victims, but the acid has an affinity for the protein molecule, and liver damage may result from prolonged exposure. Five cases of toxic effects, selected from a large group, are described, and show that thioglycolic acid can cause severe allergic reactions in sensitive people. Like other allergens, its main impact is on the skin and mucous membranes. The effect is cumulative, and sufferers have remissions after contact with the acid has been removed. The process has been applied to many thousands without ill effects, but it seems probable that repeated exposures may eventually prove disastrous to those who have been immune up to the present. It is not possible to determine in advance, without a patch test, which individuals will suffer toxic reactions. In the majority of cases recovery occurs without permanent damage to the liver when the exposure is promptly terminated. In those in which the acid acts as a systemic poison as well as an allergen the first signs of trouble are to be found in the blood count, the elevation of the alkaline phosphates, the change in the ratio of free to esterified cholesterol, and the appearance of a positive cephalin flocculation test.

Now that this product is being sold in chain stores, its indiscriminate use will result in an increased incidence of poisonings. Adequate labelling and understanding of the dangers involved are imperative.

A. Thelwall Jones.

Aplastic Anaemia following Exposure to Trinitrotoluene. SIEVERS, R. F., STUMP, R. L., and MONACO, A. R. (1946). *Occupat. Med.*, **1**, 351.

The fatalities in the 1939–45 war following exposure to TNT were remarkably small compared with 1914–18, largely because of precautionary measures. So far, 14 cases of aplastic anaemia due to TNT have been reported in the United States. Three cases are now reported. In the first, aplastic anaemia developed 3 weeks after the onset of a toxic hepatitis and terminated fatally 2½ months from onset. Necropsy revealed subacute yellow atrophy of the liver and hypoplastic bone marrow. In the second, aplastic anaemia was present for 3 months before death after sternal puncture; and in the third (non-fatal) after 6 months, signs of regeneration of the bone marrow are developing.

In the first two cases the diagnoses of aplastic anaemia was confirmed at necropsy, and in the third the diminution in all cellular elements of the blood was suggestive. In the first case, a burn 9 weeks before the onset of illness was treated with 5 % sulphathiazole ointment, and the third case had been exposed to repeated but not excessive doses of phenacetin and to benzene as a constituent of glue 2 years previously. None of these substances was thought to be causative. Exposure to TNT both in duration and intensity was slight in the first and second cases compared with most TNT workers. In the first case, the severe laboratory evidence of liver damage improved after 6 weeks but failed again 2 weeks before death. There was no sign of liver damage in the second and third cases (confirmed at necropsy in the second case). Unusually high urinary excretion of coproporphyrin (958 microgrammes per 24 hours) in the first case were attributed to hepatitis. Sudden death in the second case was clinically similar to cerebral embolism. The *Lactobacillus casei* factor (folic acid) was administered in the first case too late to determine whether the remarkable stimulation of bone marrow in animals could be reproduced. Large doses of pyridoxine were administered to the second and third cases, but unequivocal evidence of an increase in the red and white cell count was not obtained. Further trial of this substance is warranted. *T. A. Lloyd Davies.*

INDUSTRIAL PHYSIOLOGY

The Lead Content of Blood and its Relation to Rarefying Processes in Bone. BROWN, A. (1946). *Quart. J., Med.*, **15**, 77.

The metabolism of lead and calcium are know to be similar. With the evidence that the mobilization of tissue calcium by osteolytic processes may cause hypercalcaemia, the author has investigated the possibility that an analogous mobilization of stored lead may accompany these states, sufficient even to produce symptoms of plumbism. The lead in the body is derived from domestic water, especially when soft (e.g., Glasgow supplies contain appreciable quantities), and from food. It is stored in the tissues, particularly the skeleton. Deposition is most rapid in the growing animal, first in the bony trabeculae, later in cortex as the less soluble triphosphate. Lead absorbed more recently is thus stored in a situation from which it may be readily mobilized because trabecular absorption is always first to occur. This study has shown that the occurrence of skeletal rarefying disease (e.g., leukaemia, metastatic cancer, severe anaemia with hyperplastic bone marrow) may be associated with blood levels for lead considerably above normal, and that this response will be accentuated in proportion to the domestic hazard of water supply. Therefore, in circumstances associated with chronic exposure to lead in great degree, such as may happen in industry, the occurrence of osteolytic processes in bone may precipitate lead poisoning. The blood level, then, is an index not of recent lead absorption alone but of the balance struck between lead absorption and mobilization, and its excretion. The author points out that a patient may be anaemic because of lead intoxication, or that he may be suffering from lead intoxication because he is anaemic or because, for some other reason, his marrow is unusually active.

J. L. Lovibond.

Effects of High-Speed Vibrating Tools on Operators Engaged in the Airplane Industry. DART, E. E. (1945). *Occupational Med.*, **1**, 515.

A group of 112 workers who had symptoms following the use of air- or electrically-driven rotary polishing tools was studied, together with control series. The literature since 1911 shows that the possible injuries from vibrating tools consist of: (*a*) peripheral vascular disease in which 'dead fingers' are observed, though pain seldom predominates, tight gripping, vibration, and cold being likely aetiological factors; (*b*) nerve injuries, especially to the ulnar nerve; (*c*) injuries to muscles, tendons, fasciae, and ligaments; (*d*) bone and joint injuries, especially changes in elbow joint and decalcification of the carpal bones.

In the present series a medical history was taken and a physical examination made in all cases: radiographs, blood counts, sedimentation rates, and uric acid, serum calcium, and blood-sugar estimations were made in selected ones. Allen's test for patency of radial and ulnar arteries were used; plethysmograph records, photomicrographs of nail-bed capillaries, and skin temperature responses to cold, were also observed. The main symptoms were pain (68%) liable to affect both hands and the whole arms, numbness (41%) extending sometimes to the wrist, and stiffness confined to the hand (28%). No physical signs were to be seen in 55%: the remainder had slight and variable objective signs, such as swelling and erythema, but there was little clearly demonstrable peripheral vascular disease. Allen's test was of little value and the plethysmographic and photomicrographic studies have yet to be published. Skin temperatures were recorded by the patients' grasping stem thermometers in the hands, which had been immersed for 5 seconds in water at 35° F. Workers and controls sometimes produced different responses; a failure to return to the initial skin temperature within 15 minutes was taken to indicate a delayed response after cooling. The group of workers with symptoms showed a higher percentage of delayed response than either the workers without symptoms or the normal controls. Differences between the two hands were not significant. Few carpal cysts appeared on the radiographs.

In general, women seemed more susceptible to vibrations than men. The average interval before the onset of symptoms was 8 months, and twice as many cases appeared in the cold months as in the hot. The direction of the exhaust air from air-driven tools was not significant. Delayed response to cold bore little relation to the distribution of symptoms or to the hand holding the tool; nor were the various grips employed, of which photographs are shown, clearly related to the abnormalities which resulted. There was no relation between the latter and the hardness of the metal worked upon. Oscillograph records suggested that vibrations were of the order of 12,000 per minute, but the harmonics were not investigated. Patients removed from the work often had an improved response to cold thereafter; some relapsed after returning to work, and others developed a delayed response some weeks after leaving the work. On the same test, in a small series, nicotinic acid (50 mg. four times a day) or neostigmine bromide (15 mg. three times a day) caused some improvement, but not as certainly as removal from the work.

The tools were rotating at from 10,000 to 50,000 revolutions per minute; comparison with other investigations involving tools at rates below 4,000 per minute suggested that the high speed tools produce symptoms of pain, swelling, and increased vascular tone, whilst the slower tools cause less painful blanching of fingers and bony changes. It is suggested that in this series the defect was neurovascular. Right-handed patients had symptoms mainly on the right, but increased vascular tone on both sides, according to the test of response to cold. It is suggested that increased tone precedes the symptoms, and that there are probably no permanent vascular changes. Probably there is an alteration of peripheral nervous stimuli, as some other neurological signs were observed. Suggested preventive measures are a change in the process involved in favour of wet sand tumbling, reduction of exposure to cold, shielding of the exhaust blast, reduction of vibration by rubber insulation, attending to tool wear, the use of a grip as for holding a pencil, removal from exposure after injury, and adequate medical examinations.

J. N. Agate.

INDUSTRIAL LUNG DISEASE

An Investigation into the Radiological Appearances of the Chests of Workers Engaged in the Production of Toxic Gases. WHITAKER, P. H. (1946). *Brit. J. Radiol.*, **19**, 158.

The article quotes the fact that in 17,000 cases exposed to toxic gases Evans found no significant radiological change in the chest. The author reviews the work of many writers and gives the findings found at autopsy. The radiological changes can be divided into two main groups: (1) those due to exposure to toxic gases where the changes are in the hila about the main bronchi, with

the periphery clear; and (2) those due to acid fumes, where the changes are in the alveoli and, therefore, peripheral. They resemble miliary tuberculosis. In six cases of mild phosgene inhalation, the changes of a congestive type (increased hilar shadow and slight increase of reticular marking) disappeared in 14 days. Prolonged exposure to acid fumes led to punctate mottling similar to pneumoconiosis. Ninety-four men working with mustard gas were examined before they began work and again 6 months later. In six cases the author reports 'an increase in the density of the hilar shadows and changes in the character of the root markings.' Three months later there was no further change. One year after the first film, and after the men had rested from work, the chest picture was normal in four of the men while in two the shadowing remained. The changes were thought to be congestive.

M. H. Jupe.

Graphite Pneumoconiosis Complicated by Cavitation due to Necrosis. DUNNER, L., and BAGNALL, D. J. T. (1946). *Brit. J. Radiol.*, **19**, 165.

A case of necrosis cavitation in the lung of a graphite worker is described. The sputum contained graphite though the patient had not worked for five years. There was no silica in the sputum. The analysis for total and soluble silica of the graphite inhaled is given. A plea is made for post-mortem examination of such cases. [It is not easy to understand what conclusions the authors wish to draw from their discussion of the subject.]

M. H. Jupe.

Bacteriological Investigation on Pneumonia and Pneumococcus Carriers in Sauda, an Isolated Industrial Community in Norway. RIDDERVOLD, J., and HALVORSEN, K. (1943). *Acta path. microbiol. scand.*, **20**, 272.

Sauda is an isolated village in western Norway situated at the farthest end of a deep fjord and surrounded by high hills. Sudden changes in climate are experienced, with 2,000 mm. (78 inches) of rain a year. Before 1915, when the erection of a factory for the electric smelting of ferro alloys, particularly of ferro manganese, was begun, Sauda had 1,500 inhabitants. The population slowly increased to 4,500. The factory started producing in 1923, and during that year an epidemic of lobar pneumonia affected the town. Every year since, the village has had a high mortality rate from pneumonia. The mortality from pneumonia (all kinds) per 100,000 inhabitants is given as:

Sauda 1924–37	Oslo 1924–36	Norway 1924–36	U.S.A. 1933–37	Pittsburgh 1929–31	Long Beach 1929–31
326 (lobar pneumonia only)	106	82	82	217	42

The present paper is the report of an attempt during 1938–39 to survey the bacteriology of the 'Sauda' pneumonias. Of 46 cases of pneumonia, 13 were due to pneumococcus Type I, 4 to Type II, and 5 to Type III. A second attack of pneumonia was frequent. There were two cases of atypical pneumonia due to pneumococcus Type III. The age distribution of pneumonia was: 0 to 15 years, 11 cases; 15 to 30 years, 11 cases; 30 to 40 years, 3 cases; 40 to 50 years, 5 cases (2 fatal); 50 to 60 years, 9 cases (2 fatal); over 60 years 6 cases (3 fatal).

In only 6 out of the 14 cases investigated (one examination only) were contacts found to have the same type of pneumococcus in their throat. Forty-six per cent. of healthy people carried pneumococcus in their throat. A new type of pneumococcus was isolated from the throat of a healthy subject. Graphs of the incidence of carriers and cases of pneumonia disclosed that for pneumococcus Type I the highest incidence (9%) of carriers was found in September, after an outbreak of pneumonia of the same type in the months of May to July. The incidence of Type III carriers bore no relation to the occurrence of pneumonia. The incidence of carriers in employees at the smelting works was not consistently higher than in other districts.

In the districts of Sauda, Birkeland, near the factory in the direction in which smoke most frequently blows, the number of carriers was not significantly higher than in Brekke-Austerheim, which lies higher and farther away.

T. A. Lloyd Davies.

The use of Aluminium in Silicosis Control. TABERSHAW, I. R., and TEBBENS, B. D. (1945). *Industr. Med.*, **14**, 709.

This is a brief review of the principles of prophylaxis and therapy. Comment is made on the disparity often found between symptoms and radiological appearances in silicosis. It is stated that, in the presence of finely powdered aluminium or of amorphous hydrated alumina XH-1010, progression of silicotic change ceases and early fibrous change resolves. The effect of aluminium after inhalation is long (it may remain in the tissues for many months), and it produces no harmful effect (save that in large doses it may alter the tissue defences against tubercle). Gardner is quoted as stating that hydrated alumina XH-1010 (not at present available generally) is a preferable antidote, because (1) it is probably the substance ultimately produced in the body as the inhibitory agent; (2) it is stabler than metallic aluminium, hence easier to use; (3) it is easier to disperse in the air for group inhalation. In the lung the hydrated alumina coats the silica particle and renders it insoluble. Bamberger has produced equally good results in groups of men treated with each reagent.

The writers indicate that investigators who insist upon rigid criteria of objective improvement have found less impressive results than those who accept subjective evidence: no regressive changes in men treated have been radiologically demonstrated. It is stated that when aluminium prophylaxis and therapy are in use, workers (? with radiographic changes) may continue to work in a siliceous-dust environment without danger. Proof of the efficacy of aluminium prophylaxis in industry must await the passing of a few more years, since silicosis is a slowly developing disease. Dust control and prevention in industry is still the paramount aim, and medical study of the workers should not be neglected. Aluminium therapy is indicated for all silicotics still exposed to the dust, for silicotics who have been so exposed within ten years, and for workers in siliceous dust who show increased linear or reticular shadowing radiologically. Men with active tubercle or other pulmonary disease are considered unsuitable for therapy.

L. W. Hale.

Eosinophilia in Silicosis. HABERB, W. J. (1945). *Amer. Rev. Tuberc.*, **52**, 337.

In a series of patients with eosinophilia the usual causes—allergic diseases, parasitic infestations, and skin

diseases—were ruled out, and it was noticed that many were coal miners. The question of eosinophilia in silicosis needed investigation. A series of 134 miners and 582 non-miners were selected from a sanatorium population. They were divided into three groups, those with tuberculosis, with silicotuberculosis, and with silicosis, and the latter group was divided according to severity. Eosinophil counts above 300 per cubic millimeter were considered abnormal. Eosinophilia occurred in 51·2% of miners with silicosis. In miners with silico-tuberculosis the figure was 32·4%, in miners with tuberculosis it was 16·1% and in the control series 5·9%. In the second and third stages of silicosis the counts were significantly raised, and the highest individual count represents an eosinophilia of 21%. The average count in the second stage was 634, and in the third 652. There was no correlation with age or length of mining service.

It is stated that silica is unlikely to be an allergen, and that coal dust alone produces no tissue reaction and could not be responsible. Experimentally, interference with expiration has caused eosinophilia in humans, and emphysema and asthma with eosinophilia in dogs. Alternatively acidosis, as produced experimentally, is a possible cause. The respiratory physiology of silicotics is similar to that of asthmatics, and silicotics may even have bronchospasm. Emphysema is common to both, and so is alveolar overdistension with expiratory delay. Emphysema itself has once been reported as a cause of eosinophilia. *J. N. Agate.*

Bronchographic studies in Advanced Silicosis. BRUCE, T., and JÖNSSON, G. (1943). *Acta radiol.*, **24**, 206.

A bronchographic study was made of 5 cases of silicosis with massive lesions, in order to demonstrate distortion, dislocation, and occlusion of branch bronchi. In 4 cases the massive lesion was typically situated (behind, above and lateral to the hilum), and in one it was basal. In the first group the alteration in bronchial topography (due to traction of the fibrous tissue in the mass, and perhaps to compensatory expansion of the lung adjacent to it) was consistent, suggesting that the ventral branch bronchi were most displaced, being drawn upward and backward; the dorsal branches showed less dislocation (the lower dorsal ones none). Massive fibrosis of typical location was situated mainly in the distribution of the eparterial and first hyparterial bronchi; branches traversing the lesion were commonly occluded; dislocation was maximal in the part of the bronchus nearest its origin from the stem, and less at the periphery, so that upward 'humping' of the proximal part of the affected branch bronchus resulted. Deformity caused by atypically situated masses is variable, but appears to follow the pull from the centre of contraction as would be expected. *L. W. Hale.*

The Prevention and Suppression of Coal Dust in Mines. SMITH, H. W., and BANKS, H. F. (1945). *Trans. Inst. Mining Engrs.*, **104**, 602.

Coal dust in the mine constitutes a threefold risk: (*a*) of explosion, (*b*) of pulmonary disease, and (*c*) by diminishing visibility in workings it conduces to the incidence of accidents. In one mine studied, coal dust was deposited at the rate of 0·51 lb. per ton of coal produced. Machine-cutting is the main cause of fine coal-dust production, the amount varying with: (1) the nature of the coal—the more the coal will splinter (rather than powder) when cut, the less the dust; (2) the design, setting, speed, and good maintenance of the cutter-picks. These should splinter rather than abrade the coal-face. The thinner the jib which carries the cutter-pick chain, the less the dust. When cutting at floor-level a mechanical gummer is necessary to ensure that the fine dust caused by the picks shall not be swept round by them and re-ground at the face. When cutting is above floor-level there is an added risk, as dust is swept out of the cut and directly suspended in the air. There is usually no dust problem if the seam contains over 6% of moisture; if less than this, wet-cutting is desirable. The method of wet-cutting used consists of two water jets, one directed upon the ingoing, and one upon the outgoing side of the cutter-pick chain: this produces an 84% reduction in the dust collected in deposition-trays at the face.

Drills for shot-holes should be designed and speeded to produce coarse drilling-particles rather than fine. In blasting, the use of low-density explosives and suitable stemming, and firing of shots in groups rather than separately, have reduced dust-production. Blasting should fragment rather than shatter the coal.

Points of transfer from one conveyor to another, or to the tub, are the main source of dust in the transport system. Water-sprays at these points, if used 'open,' have the defect that they damp the dust cloud and cause it to settle on the roadways, etc., where it dries and is easily redispersed: these sprays should work in a 'shroud' which encloses the transfer point. Diagrams are given showing the advantages of such enclosed sprays and percentage figures of dust-reduction. Where compressed air is available, mist-projectors (which atomize the water) are preferable to water-sprays. The use of brushes to clean off the dust adhering to the conveyor-belts is advocated (800 lb. fine dust were collected from a return belt in a single shift conveying 300 tons of coal). The amount of fall in transferring coal from one conveyor to another should be minimized in order to avoid breakage of the coal. An improved type of conveyor-discharge loader, operating without water-sprays, is described; this is entirely enclosed in a sheet-steel casing with rubber flaps to prevent escape of dust at the points of entry of the conveyor-belt; it is said to give a 60% reduction in concentrations of dust particles below 5 micron size. This method of mechanical inhibition of dust-escape in loading results in an increased transportation of fine dust to the surface, with increased dust-risk in surface operations, especially in the tippler. It is suggested that this difficulty is met by the use of steam jets at surface (these act by causing condensation on the dust-particles).

Dust sampling in this study was mainly done with deposition trays and filter tubes; dust concentrations are expressed gravimetrically. Particle sizes are expressed in mesh-gauge measurements. Water infusion into the coal face is not discussed. *L. W. Hale.*

The Facts Concerning the Use of Aluminium and Alumina in the Prevention and Treatment of Silicosis. (Hechos nuevos sobre el empleo del aluminio y de la alumina en la prevencion y el tratamiento de la silicosis.) POLICARD, A. (1946). *Gac. med. esp.*, **22**, 363.

INDUSTRIAL PSYCHOLOGY

Application of Military Mental Hygiene to Industry. COHEN, R. R. (1946). *Occupat. Med.*, **1**, 333.

Bad job adjustment, whether in the army or industry, means frequent transfers, repetition of training, absence

without leave, unnecessary sickness, and emotional illness. The problems are (1) adjustment to job, (2) early handling of the maladjusted, (3) attitude conditioning. Explanation of the causes of resentment, fear, homesickness, and anxiety, was given to conscripts and to officers and N.C.Os; each soldier was also given a book of humorous cartoons illustrating particular points. A group of men given such explanations suffered less emotional illness than a control group. For the second problem, maladjusted men were sent to a consultation service, consisting of a psychiatrist, a psychologist, a job personnel consultant, and a social worker. Individual problems were elucidated by case work. For the maladjusted soldier, a puppet show was chosen as a visual medium of explanation. For the third problem, wall diagrams were used to explain the reason and suggest the need for otherwise inexplicable demands made by authority. For example, the soldiers returning from Europe were mentally conditioned for service in the Pacific by an exhibition, 'There is still the Jap.' The author suggests that this method can be applied to industry—for example, 'There is still the preventable accident.' *T. A. Lloyd Davies.*

INDUSTRIAL DERMATITIS

Occupational Dermatitis. HALL, M. I., and others (1946). *Connect. State med. J.*, **10**, 187.

This is a report of 368 cases of dermatitis resulting from processing steel in the motor industry. In all operations the steel is covered throughout, more or less, with grease and oils. Petroleum compounds in this order of importance caused 92·4% of cases: soluble oil (emulsions and grinding), cutting oils, mineral seal oil (very potent irritant), rust preventives and slush oils, petroleum solvents, light mineral lubricants. Chromic acid cleaning compounds and miscellaneous chemicals made up the total. The highest incidence was in automatic machine operators and tool adjusters. A far smaller incidence occurred in grinders, janitors, stock handlers, inspectors, and wrappers. Clinically, mineral seal oil showed greater liability than cutting oils and emulsions to produce erythema, pruritus, and vesication, and less tendency to cause papules, comedones, and pustules.

Personal cleanliness in prevention and treatment is advocated, and 88% of cases improved with energetic washing. That workers will not always use washing facilities, even when provided, was shown by an estimate that in three places 2%, 19% and 38% of persons did not wash or clean up on the plant.

Geoffrey A. Hodgson.

Erysipeloid. KING, P. F. (1946). *Lancet*, **2**, 196.

A survey was made of 115 cases of erysipeloid seen between May, 1941, and December, 1945, comprising 5% of patients attending a septic hand clinic. The disease was usually confined to catering workers and is, therefore, occupational. Its synonyms are erythema serpens, erythema migrans, chronic erysipelas, and fish handler's disease. The causal organism is *erysipelothrix rhusiopathiae*, occurring in organic matter and entering through puncture wounds or bites. The infecting material here was fish in 25%, poultry in 21%, and meat in 20% of cases. Two-thirds of those in whom the infecting agent was uncertain were from the catering trades; 88 of the 115 cases were attributable to an animal source.

The lesion develops in from 2 to 7 days, is well-defined and purple-red in colour, and spreads centrifugally from the fingers. It causes discomfort, pain, and interphalangeal joint stiffness, and is sometimes associated with general disturbances, occasionally with regional lymphadenitis. Regression and relapse are usual; the duration is usually from 14 to 28 days, and the final fading is centripetal. The disease is seasonal in summer and early autumn, during periods of prevalent swine erysipelas. Flies are a possible vector. Cooks and housewives account for 50% of cases. Immunity is not conferred by one attack. Treatment consists of rest for the affected part. Of the sulphonamides, sulphathiazole gave the worst results. Local applications and chemotherapy all produced similar results, but none better than rest alone. Serum has been recommended elsewhere in spite of serum sickness. Systemic penicillin has warm advocates, but was not used in this series.

J. N. Agate.

The Use of Penicillin in Acute Infections of the Hand. CURR, J. F. (1945). *Edinb. med. J.*, **52**, 469.

Three hundred cases of acute infection of the hand (omitting minor infections such as paronychia, early pulp and sub-epithelial infections, lymphangitis, cellulitis, and hair follicle infections) were treated with penicillin and compared with a control series. Cases were treated surgically as indicated. The use of penicillin in crude filtrate in the wound (used in 50 cases) was found to be undesirable; penicillin in lanette wax cream placed in the wound proved unsuitable and had no beneficial action. Some success attended the use of penicillin powder placed in the wounds, though this could be done only under anaesthesia. Continuous intramuscular penicillin drip gave encouraging results in acute suppurative tenosynovitis. Intramuscular injection of penicillin in wax or oil was unsatisfactory. Uninfluenced by any method of treatment, necrosis was the principle cause of retarded healing. *T. A. Lloyd Davies.*

GENERAL

Industrial Management and Occupational Cancer. HUEPER, W. C. (1946). *J. Amer. Med. Ass.*, **131**, 738.

Proof of the carcinogenetic properties of a number of important substances and physical agents in common use in industrial processes has been obtained by reproducing the same tumours in animals. Nevertheless there are still many human occupational cancers of unknown aetiology. These are likely to appear after 5–15 years' exposure. After enumerating the pathological conditions which may accompany certain trades, a plea is made for industry to devote more effort to the study of occupational cancer, especially of its cause, prevention, and control. Several points are listed as a basis from which to wage an attack. Among these are the safety construction of buildings and plant to eliminate poisonous substances in manufacture, leak-proof packing and storage, the full protection of personnel, adequate medical supervision and follow-up, the compulsory notification of cancerous and precancerous industrial diseases, compensation, regular government inspection of factories, and the formation of a consultative committee well versed in the scope of industrial cancer.

J. L. Lovibond.

Industrial Medicine. HUNTER, D. (1945). *Practitioner*, **155**, 270.

Industrial medicine, with emphasis upon recent advances, is reviewed. It has been found that longer

hours of work cause output to decline, and that rest pauses can increase output from 5–10%. It is suggested that the industrial medical officer and the illuminating engineer both need to know the best conditions for the workers. The author states that in hot, unventilated workrooms output falls off in the summer; accident rates rise with both unduly high or unduly low temperatures, and the optimum for munition workers has been shown to be 67° F. He advocates using vocational psychology tests to apportion tasks suitably rather than to reject the unfit. It has been found that mechanical guarding of machinery will only reduce accident rates by 10% Work on 'accident proneness' has revealed that most accidents occur among 10–25% of people. Uniform sickness records on the lines suggested in the Industrial Health Research Board's Report (1944) are recommended.

Treatment of septic wounds and occupational dermatitis is discussed. In the field of poisoning by metals it is noted that the physical state of the metal often determines its activity. Lead absorption is greatest from lead fume, and depends on the solubility of the compound. Basophil punctation is more often found in sternal marrow cells than in circulating red cells. Mercury fungicides used in agriculture may burn the skin, and methyl mercury derivatives specifically attack the nervous sustem, so manufacture must be by completely enclosed processes. Toxic effects have been observed in the case of the following rarer metals, beryllium, cadmium, platinum, selenium, tellurium, thallium, uranium, and vanadium. Uranium causes chronic nephritis and hepatic degeneration in dogs.

The structure of derivatives of coal-tar partially determines their toxicity, which is to some extent predictable though this does not apply to the toxicity of isomers. The measures against benzene poisoning are strict and have been applied with great success. Recently, very variable blood pictures have been reported from this cause, revealing anything from hypoplasia to leukaemia, but in the present day 'dope shops' the hazards are negligible. Triorthocresyl phosphate is a plasticizer, and cases of polyneuritis have followed its use in industry. Methyl bromide causes burns locally, or neurological signs and even death from pulmonary oedema. Chlorinated Naphthalene causes acne of the face or necrosis of the liver with toxic jaundice, which is often fatal. Elaborate preventive measures have been devised. Cadmium attacks the respiratory system and may cause bronchopneumonia. Beryllium causes an acute bronchiolitis. Vanadium causes chronic bronchitis. Bagasse, the dry residue of extracted sugar cane, causes acute bronchiolitis, pulmonary collapse, and pneumonia, which may proceed to fibrosis of the lungs with great dyspnoea. Asthma is caused by the complex salts of platinum, but not by dust from spongy platimum. Arsenic may, perhaps, cause neoplasm of the lung, and this element may have been the cause in the cases from the Scheeberg mines.

Work in South Wales on anthraco-silicosis of miners has led to favourable modification of the Workmen's Compensation Act. The effect of aluminium dust on lungs is in dispute. Ill-effects are reported from Germany but are not confirmed in Canada or England.

Iron oxide cause radiological signs of reticulation and modulation in the lungs, without evidence of actual fibrosis; it is seen in welders and silver polishers. Boiler scaler's disease is due partly to silica and partly to iron oxide. Treatment of dust diseases of the lung should be preventive, by reduction of the dust by all possible means, and substitution of non-siliceous materials where possible. Detailed suggestions for foundries have been officially made. *J. N. Agate.*

What the Farm Bureau Expects from Medicine. JONES, J. S. (1946). *Connect. State med. J.*, **10**, 294.

Interest shown by farmers in such problems as tuberculosis control in cattle and man, the epidemiology of undulant fever in relation to contagious abortion in dairy herds, the rejection for the armed forces on medical grounds of their rural youth, and the work of the Blue Cross, has focused increasing attention on the whole problem of rural health. The American Farm Bureau Federation, with the American Medical Association, have agreed on the need for the farmer to work with the medical profession and to investigate the possibilities of social medicine in rural practice. The institution of some form of prepaid medical service seems desirable. At present the rural population is short of doctors and of adequate hospital facilities. *J. L. Lovibond.*

What Industry Expects of Medicine. STRONG, H. (1946). *Connect. State med. J.*, **10**, 296.

The goal of the health service in industry and the qualities of the ideal industrial medical officer are here outlined by a layman. The industrial manager, the author says, should understand how the medical service can help him to attain the economic objective of reduced absenteeism, increased efficiency of the employee, and increased production. Industrial medicine requires special training. The physician must familiarize himself with the facilities of the plant, with the hazards of the industrial process, and with the environmental conditions in the factory. He must understand the personal problems, mental health, and capacity of the workers, realizing that, while his salary is paid by the management, his professional responsibility is primarily to the employee. He should maintain the normal confidential relationship of a private doctor to his patients. Periodic health examinations should be made, with an adequate follow-up. There should be a comprehensive educational programme for the employees, stressing the preventive aspect of medicine. A cooperative liaison with the community health authorities (92% of absenteeism due to illness arises from causes outside the factory) should be built up. The physician does not usually practise curative medicine in the factory, except for minor ailments and emergencies, but refers the employees to their family physician. Only the high personal integrity of the factory doctor will overcome the natural suspicion with which employees may tend at first to view a newly instituted plant health service.
J. L. Lovibond.

What Labour Expects from Medicine. CRUICKSHANK, N. H. (1946). *Connect. State med. J.*, **10**, 300.

The author says that working people know from hard experience that ill health undermines security and that they want to feel in future that competent modern and scientific medical care will be available to them and their families when it is needed. He says that the majority, however, are not prepared to pay for it except on the budget basis of a compulsory social insurance, which they would welcome, and that a unified contributory principle in social insurance would improve the doctor–patient relation by removing the financial barrier between them. The provisions of the Wagner-Murray-Dingell (1945) Bill assure a free choice of doctor, dentist, or nurse. Plans for hospital construction and a comprehensive maternal and child health and welfare pro-

gramme are included. Power would be given to representative advisory bodies, which, on matters of strictly professional concern, would consist solely of medical personnel. Figures are quoted which reflect that the present public health situation in America is not satisfactory. The author considers that the provision of adequate medical care for the community in the future is the aim of a democratic national health programme, and that health services should not be for the privileged few but for the workers and families of all America.

J. L. Lovibond.

Teamwork for Industrial Health. BLOOMFIELD, J. J. (1946). *Amer. J. Publ. Hlth.*, **36**, 261.

In appealing for a concerted effort on the part of public health agencies, the medical profession, industry, and labour, the author suggests that four types of service are needed in an industrial health programme: (1) a safe and healthful working environment; (2) adequate medical and nursing services and a properly equipped dispensary; (3) feeding facilities for workers on all shifts; (4) welfare services to cover personal problems, recreation, and other activities which contribute to morale and healthful living. It is said that the fundamental services are available in America to-day although deficiencies do exist, for example in numbers of trained personnel, in adequate hospital and health centre accomodation, in sanitary facilities, and in research facilities into medical problems. Many of these services have been greatly developed during the past 10 years, but the chief requirement now is the harnessing of all the potential power into a co-ordinated programme in which all the community will take an active part. *A. Lloyd Potter.*

Superficial 'Burns' of Skin and Eyes from Scattered Cathode Rays. ROBINS, L., AUB, J. C., COPE, O., COGAN, D. G., LANGOHR, J. L., CLOUD, R. W., and MERRILL, O. E. (1946). *Radiology*, **46**, 1.

This is an important paper describing the injuries received by six men as the result of a few seconds' exposure to scattered electrons from a 1,200 kV. electrostatic unit. It emphasizes the danger of scattered as well as direct cathode rays. Accounts of the effects and dangers of exposure to direct cathode rays are plentiful, such effects being similar to those of *x* rays but limited to the more superficial tissues of the body. No published warning about scattered cathode rays has, however, been traced. The persons affected stood not less than three feet from the direct cathode beam and at right angles to it. The total time of exposure was not more than two minutes. There is a very careful description of the movements of the men and their actions, and of the physical factors. Ionization measurements were made to estimate the dose and depth of penetration. It was estimated that the intensity diminished rapidly beyond 1 mm. in depth, being zero at 3·1 mm. At a distance of 100 cm. from the cathode port the skin dose to the face was probably 1,000 *r* units, in 20 seconds, while that to the hands was 2,000 *r* units. The clinical effects were in three phases. First, a superficial reaction subsiding in 7 days. Secondly, deeper and more widespread burns of longer duration appearing when the first phase had subsided. Thirdly, about 4 weeks after exposure, more extensive involvement affecting new areas, as well as those already healing after the first and second phases. Thin clothing gave protection against the reaction in the first phase, but not against the other phases. One man had severe ocular signs. Full notes of the history and progress of each case are given. *M. H. Jupe.*

Health of Workmen. TOURANGEAU, F. J. (1946). *Canad. med. Ass. J.*, **54**, 352.

An investigation was made into health conditions of workers in various industries in the Province of Quebec. The inquiry included 3,384 industrial establishments employing 146,469 workers. Such conditions as dust, noise, and temperature were classified according to their degree. Noise was found to be a very common condition, over 22,000 workers being exposed, of whom 10,000 were in the textile industry. More than 3,000 workers were exposed to excessive heat. More than 6,000 workers were found to be exposed to dust hazards, and probably this figure is well below the actual number. Ventilation is the chief method of protection. About 75% of claims on the Workmen's Compensation Commission of Quebec are based on industrial dermatitis. More than 16,000 workers were found to be exposed to various irritants in their work, especially important poisonous substances being lead, benzol, and mercury.

It is felt that the amount of illness due to occupation is greater than is generally supposed, especially taking into account the conditions that bring about ill health gradually. The paper deals with a very varied list of occupational hazards, including some in munition plants, and should be read in its entirety. It concludes with an appeal for co-operation between the doctor in the plant, the family physician, and the management.

A. Lloyd Potter.

Electric Ophthalmia. WOODWARD, L. K., Jr. (1946) *U.S. Naval med. Bull.*, **46**, 247.

Over a period of three months a total of 47 cases of flash burn of the eyes, or electric ophthalmia, were treated aboard a repair ship. The greater number of cases occurred in shipfitters and other men working in the immediate vicinity of the welders, usually only a few feet away. There were no cases in men who had worn protective goggles or hoods whenever welding was being done. The findings were principally a mild to severe injection of the conjunctiva, and episcleral injection. In five instances there was considerable oedema of the eyelids, upper and lower. In six men there was evidence of pseudopterygium with accompanying injection. Superficial ulceration of the cornea was present in two cases. The response of all cases to therapy was prompt, and the problem is one of prevention. Goggles and hoods give adequate protection againt flash burns of the eyes.

A. Thelwall Jones.

Accomplishments and Further Needs in Industrial Eye Protection. (In English and French.) RESNICK, L. (1946). *J. ophthal. soc.*, **3**, 14. (1 fig.)

Plans of Organization of an Industrial Health Program. BAIRD, V. C. (1946). *Dis. nerv. System*, **7**, 273.

Medicine and Industrial Research. KETTERING, C. F. (1946). *J. Mich. med. Soc.*, **45**, 1,063.

Certain Medical Aspects of the New Law of Accidents to Workers. (Alguns aspetos medicos da nova lei de acidentes do trabalho.) LEME, J. de Moraes. (1946). *An. paul. Med. Cir.*, **52**, 15.

Health Hazards in the North Staffordshire Pottery Industry, 1688–1945. MEIKLEJOHN, A. (1946). *J. roy. sanit. Inst.*, **66**, 516.

PROCEEDINGS OF THE ASSOCIATION OF INDUSTRIAL MEDICAL OFFICERS

SCOTTISH GROUP

Minutes of the Annual General Meeting, held on Wednesday, October 30, 1946, at the Institute of Hygiene, University of Glasgow.

Dr. D. M. Watson, Medical Officer, Messrs. Stewarts and Lloyds, Ltd., took the chair. In opening the meeting, he welcomed Dr. Meiklejohn and Dr. Rogen, Reader and Lecturer in Industrial Hygiene at the University of Glasgow.

The minutes of the last meeting were read and adopted.

The secretary intimated that he had received no nominations from members of the group for the various offices to be filled at this meeting. Dr. Meiland intimated his desire to resign from the Executive Committee, and this was accepted with regret. Dr. Meiland, however, assured the group that he would continue to give his support. The following members were elected: Hon. Secretary, Dr. George Buchanan; Hon. Treasurer, Dr. Edward Collier; Executive Committee, the Chairman, Hon. Treasurer, Hon. Secretary, Dr. H. M. Roberts (ex officio), and Dr. Grace Smith, Dr. D. G. Robertson, Dr. J. Fleming, Dr. J. B. Lynch, Dr. J. W. Henderson, and Dr. A. S. Rogen.

The Hon. Treasurer read his financial statement for the year. The meeting then dealt with a letter from the Hon. Secretary of the Association, Dr. Pringle, who requested that consideration be given to the possibility of holding the May meeting of the Association in Glasgow. After considerable discussion it was agreed that this would not be practicable, but it was thought it would be possible to do something in 1948. The Secretary (Scottish Group) was instructed to write Dr. Pringle and inform him of the meeting's conclusions.

Arrangements were made to hold the following meetings during 1946–47: Wednesday, Dec. 11, 1946, at 3 p.m., Institute of Hygiene, Glasgow University, symposium on industrial health, by Professor T. Ferguson and assistants; Wednesday, Feb. 5, 1947, at 3 p.m., the Skin Department, Royal Infirmary, Glasgow; March, 1947 (date to be arranged), Mr. Barnes, Orthopaedic Surgeon, Western Infirmary, Glasgow; May, 1947 (date to be arranged), Members' Day.

The meeting then went on to consider measures for the improvement of attendances at group meetings and liaison with the Industrial Health Department of the Institute of Hygiene.